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Summer and Fall Small Mammal Sampling in Pueblo, Guaje, Acid, and Los Alamos Canyons, 2002

Los Alamos
NATIONAL LABORATORY

Edited by Hector Hinojosa, Group IM-1
Prepared by Teresa Hiteman, Group RRES-ECO

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Rhonda Robinson
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CONTENTS

List of Tables

List of Figures

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ABSTRACT

A small mammal survey was performed as a line of evidence to assess potential adverse effects in Los Alamos and Pueblo Canyons from metals, polychlorinated biphenyls, pesticides, and radionuclides. The small mammal surveys are part of a larger investigation of the affected media in Los Alamos and Pueblo Canyons being conducted by the Environmental Restoration Project. We saw some differences in species composition, sex composition, and reproduction status among the four investigation sites (Los Alamos, Acid, Pueblo, and Guaje). Guaje Canyon was selected as a "reference" location and is similar in elevation and vegetation to the Los Alamos Canyon and Pueblo Canyon sites. Differences in species composition are most likely a result of differences in habitat. Guaje Canyon and Pueblo Canyon trapping areas were both in fairly wide canyon bottoms and Guaje Canyon had a higher percent of grassland habitat. Sex composition was similar between the canyons with a few exceptions. Reproductive status of males and females differed slightly among the canyons. Pueblo Canyon and Acid Canyon had the highest density estimates and Guaje Canyon had the lowest densities. Although the majority of density estimates and daily capture rates declined from summer to fall for most of the canyons the summer capture rates were higher than historical data in most cases. The data collected from the three investigation canyons (Acid, Los Alamos, and Pueblo) did not show adverse population characteristics when compared to Guaje Canyon. The differences observed among the canyons are most likely related to differences in habitat, environmental conditions (drought and weather), and trapping pressure.

INTRODUCTION

A biological investigation of Los Alamos (LA), Pueblo, and Acid Canyons in Los Alamos County, New Mexico, was planned to provide lines of evidence on the potential for adverse effects from presence of chemicals of potential ecological concern (COPECs) in affected media. Lines of evidence were selected through meetings with Los Alamos National Laboratory personnel and their contractors, New Mexico Environment Department Hazardous Materials Bureau staff, and representatives from the Department of Energy (Katzman 2002). A small mammal study was initiated as one of the lines of evidence to assess whether potential adverse effects were evident in the canyons due to the presence of COPECs in the terrestrial media. Guaje Canyon, a canyon on adjacent U.S. Forest Service property, was selected as a "reference" canyon because of its similar topographical characteristics and no known contaminant sources. The objectives of the small mammal investigation were to determine the abundance and diversity of small mammal species and to determine the reproduction status of these animals. Small mammal trapping took place in summer and fall of 2002. This report provides the results from both trapping periods.

The category 'small mammal' generally includes ground-dwelling species with body weights ranging from 6 to 900 g such as shrews, mice, voles, chipmunks, gophers, wood rats, rock squirrels, and tree squirrels. Small mammals are low in the food chain, have relatively short life spans (less than one year), and small home range (usually 100 m^2). In addition, they are usually easy to capture and are abundant, depending on habitat and environmental conditions (Talmage 1989).

METHODOLOGY

Trapping grids were set up in Pueblo Canyon (Figure 1), Acid Canyon (Figure 2), LA Canyon (Figure 3), and Guaje Canyon (Figure 4) during June to July and October to November 2002. The Guaje Canyon site was selected as the "reference" canyon based on similar topography, elevation, water presence and quantity, and vegetation and lack of contaminants.

Site Description

Pueblo Canyon

The Pueblo Canyon site was located in the bottom of Pueblo Canyon adjacent to and southwest of the Los Alamos County sewage treatment plant and near the confluence of Bayo Canyon and Pueblo Canyon. The canyon in this area is characterized with steep

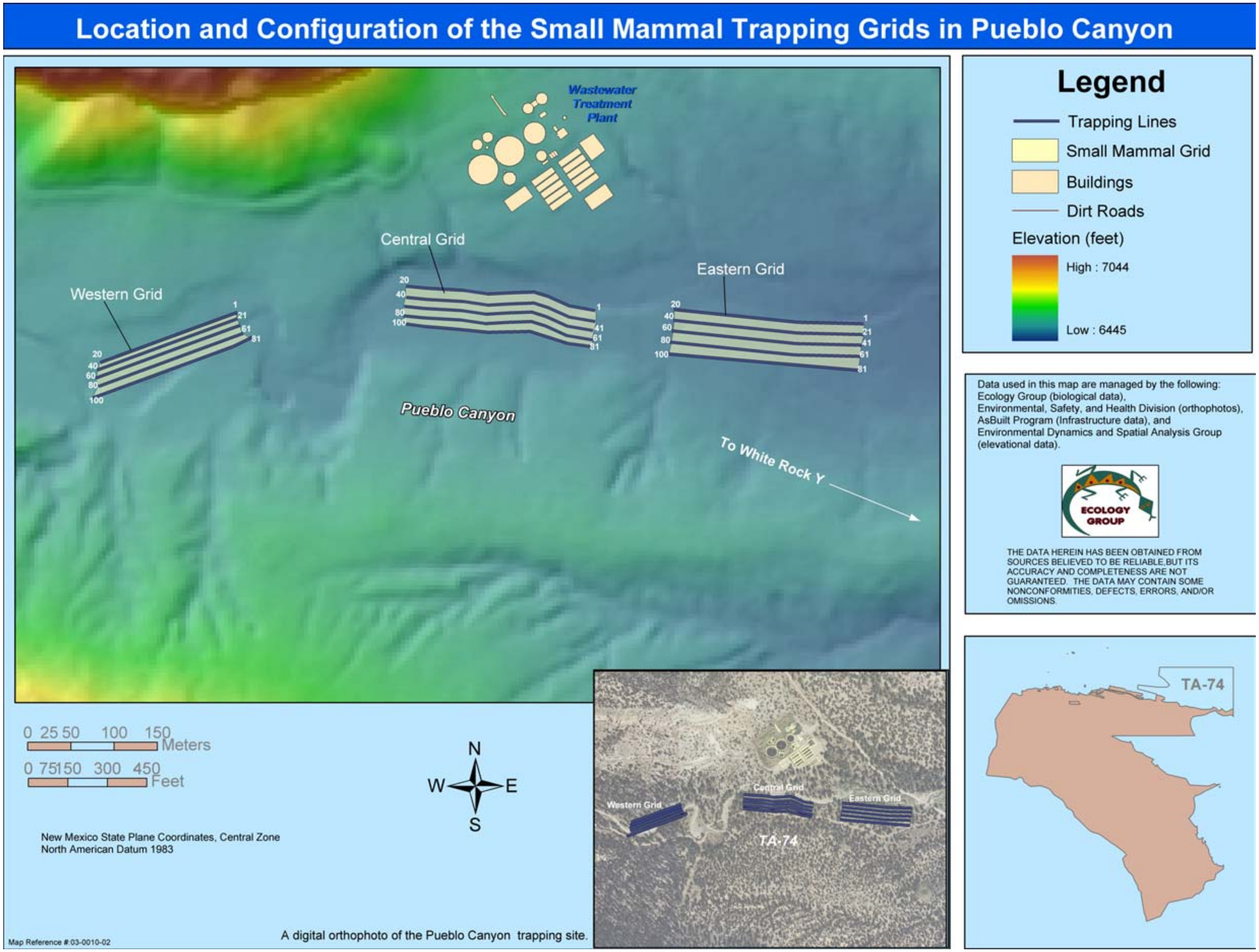


Figure 1. Location and configuration of the small mammal trapping grids in Pueblo Canyon.

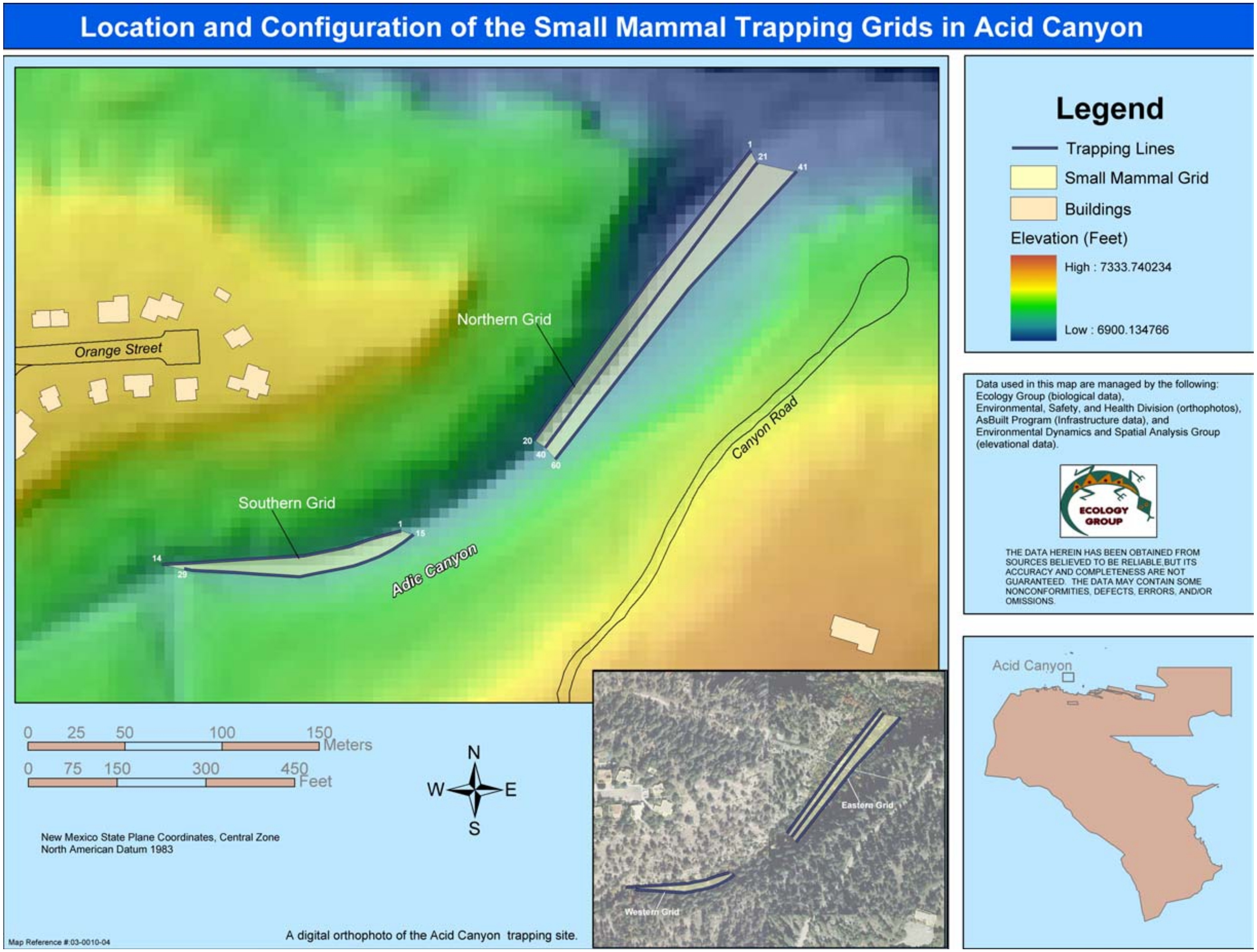


Figure 2. Location and configuration of the small mammal trapping grids in Acid Canyon

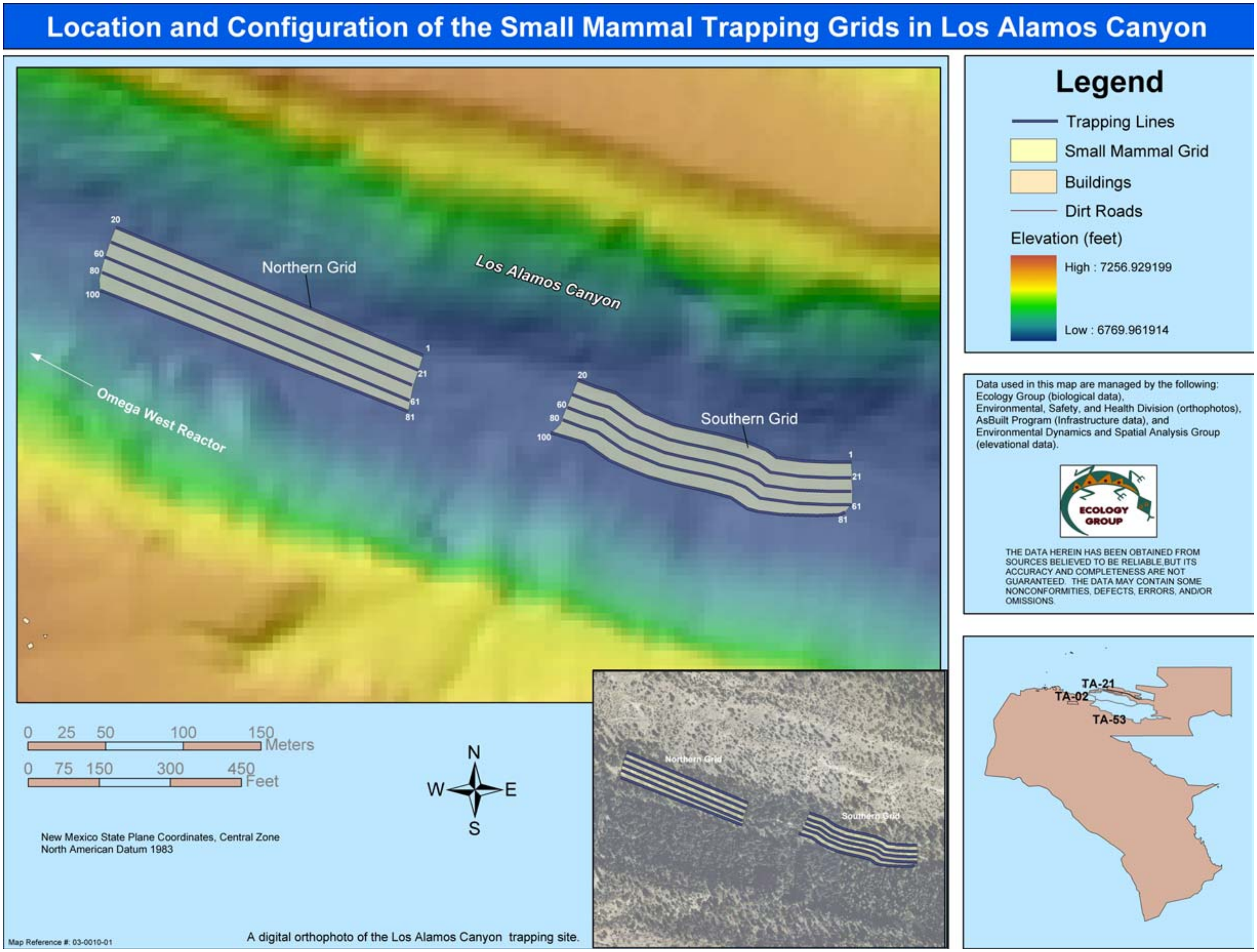


Figure 3. Location and configuration of the small mammal trapping grids in LA Canyon.

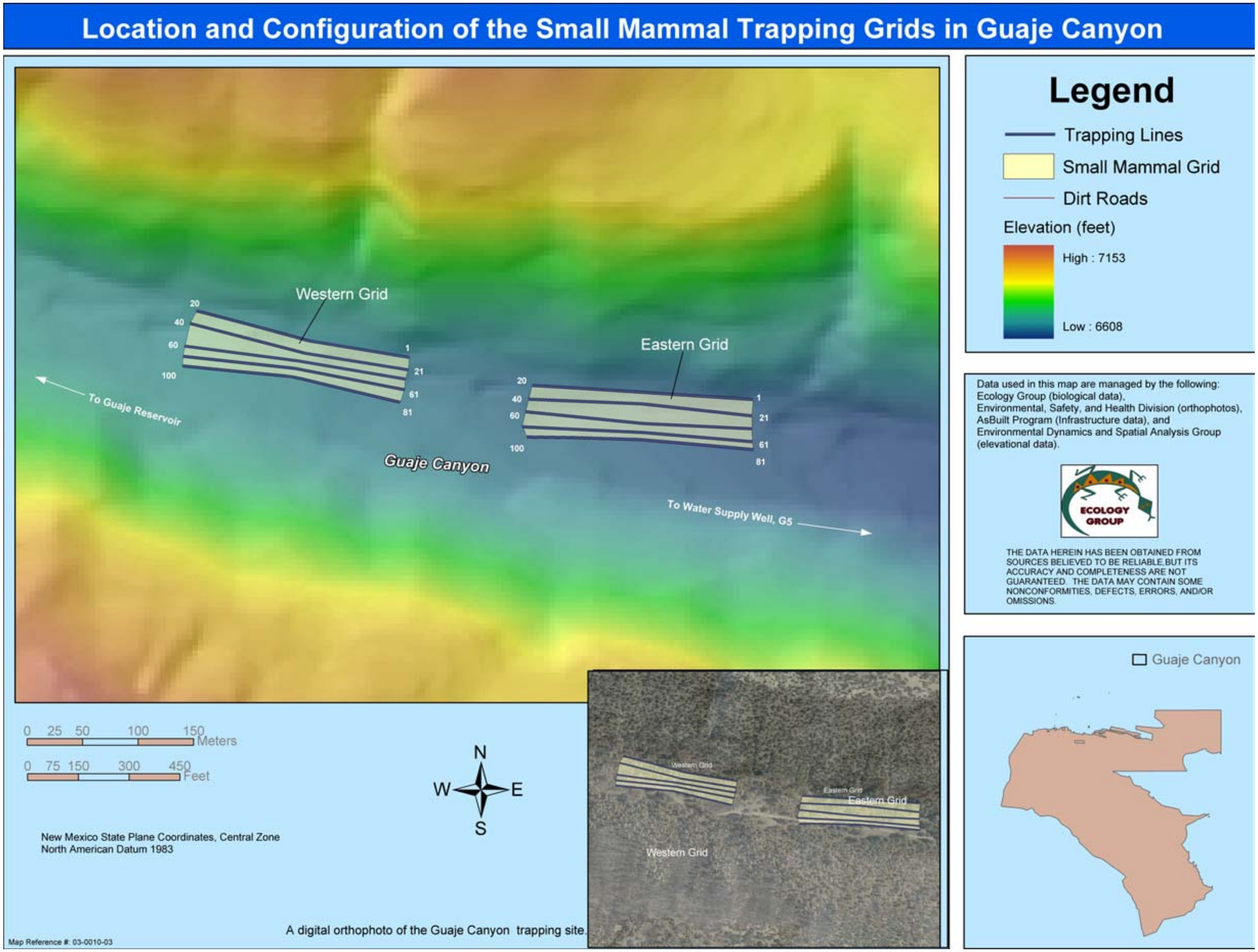


Figure 4. Location and configuration of the small mammal trapping grids in Guaje Canyon

upper slopes that gradually slope toward the flat canyon bottom that measures approximately 500 to 350 ft wide. Elevation of this canyon bottom site ranges from 6475 ft to 6515 ft. The site is dominated by a ponderosa pine overstory with one-seed juniper and piñon pine scattered throughout the site. Shrubs such as Gambel's oak, wax currant, and skunkbush are also found within the site. The understory is comprised of a variety of grasses (blue grama, mountain muhly, little bluestem, and sand dropseed) and forbs (wormwood, goosefoot, wild chrysanthemum, sagewort, redroot amaranth). The National Wetland Inventory (NWI) has characterized this stream channel in this area as riverine, intermittent, streambed, and temporarily flooded (U.S. Fish and Wildlife Service 1990). The stream channel that goes through this site is usually dry with flowing water only occurring immediately after a storm event or during spring runoff from snowmelt. However, the portion of the stream channel that is downstream from the sewage treatment plant receives effluent water and often has surface flow.

Trapping in Pueblo Canyon occurred in early July 2002 (summer session) and in late October 2002 (fall session). During the summer session, day temperatures were warm with highs in the 80's with intermittent rainstorms in the afternoon. During the fall trapping session, day temperatures were in the 50's with nighttime temperatures dropping into the 30's.

Acid Canyon

The Acid Canyon site was located in the bottom of Acid Canyon. However, Acid Canyon is a very short and narrow canyon only about 150 ft wide at the confluence of Pueblo Canyon and narrowing as you go up the canyon. The width of the canyon at the trapping sites ranged from 160 ft to less than 60 ft. Elevation of this canyon bottom site ranges from 6945 ft to 7178 ft. A mixed conifer and ponderosa pine overstory and a thick shrub layer of oak, skunkbush, wood rose, and barberry characterize the canyon. The understory vegetation is made up of mainly forbs such as clematis, Fendler's meadowrue, and western red columbine. The NWI did not characterize this stream channel. However, the stream channel properties are similar to a riverine, intermittent, streambed, and temporarily flooded classification. This stream channel is usually dry with flowing water only occurring immediately after a storm event or during spring runoff from snowmelt. During our trapping session the stream channel was mostly dry with a few wet and pooled areas after summer and fall rainstorms.

Trapping in Acid Canyon occurred in the middle of July 2002 (summer session) and in late October 2002 (fall session). During the summer session, day temperatures were warm with highs in the 80's with intermittent rainstorms in the afternoon. During the fall trapping session in Acid Canyon a cold front moved through and day temperatures were in the 50's with nighttime temperatures dropping into the low 30's. During the fall trapping, rain mixed with sleet and snow occurred during the afternoon as well as during the late evening and through parts of the night.

LA Canyon

The LA Canyon site was located in the canyon bottom of LA Canyon just downstream (east) of Technical Area (TA) 02, Omega Reactor. The canyon in this area is characterized with steep slopes and a canyon bottom measuring approximately 350 ft wide. Elevation of this canyon bottom site ranges from 6800 ft to 6860 ft. The site is dominated by a ponderosa pine overstory with water birch found along the stream channel and an occasional rocky mountain juniper and white fir within the site. The understory is composed of a variety of grasses (blue grama, little bluestem, nodding brome, and smooth brome) and forbs (wormwood, wild chrysanthemum, skyrocket, Fendler's ragwort, and threadleaf groundsel). The site has a stream channel that runs through it. The NWI has characterized this stream channel as riverine, intermittent, streambed, and temporarily flooded (U.S. Fish and Wildlife Service 1990). This stream channel is usually dry with flowing water only occurring immediately after a storm event or during spring runoff from snowmelt. During our trapping session the stream channel was mostly dry with a few wet and pooled areas after a fall rainstorm.

Trapping in LA Canyon occurred in July 2002 (summer session) and in October 2002 (fall session). During the summer session, day temperatures were warm with highs in the 80's with intermittent rainstorms in the afternoon. During the fall trapping session in LA Canyon a cold front moved through and day temperatures were in the 50's with nighttime temperatures dropping into the 30’s. During the fall, rain occurred during the afternoon as well as during the late evening and through parts of the night.

Guaje Canyon

The Guaje Canyon site was located in the canyon bottom of Guaje Canyon on U.S. Forest Service property. The canyon in this area is characterized with steep slopes and a canyon bottom measuring approximately 350 ft wide. Elevation of this canyon bottom site ranges from 6635 ft to 6700 ft. The site is dominated by an open ponderosa pine overstory with water birch found along the stream channel and an occasional Rocky Mountain juniper within the site. The understory is composed of a mostly grasses (blue grama, little bluestem, nodding brome, and smooth brome) with a limited number of forbs (wormwood, wild chrysanthemum, and skyrocket). Portions of the site could also be considered grasslands. This site had a slight to moderate burn from the Cerro Grande fire that occurred during the spring of 2000. Some overstory vegetation was burned or scorched but in our site most understory had recovered. The site has a stream channel that runs through it. The NWI has characterized this stream channel as riverine, intermittent, streambed, and temporarily flooded (U.S. Fish and Wildlife Service 1990). This stream channel is usually dry with flowing water only occurring immediately after a storm event or during spring runoff from snowmelt. During our trapping session the stream channel was mostly dry with a few wet and pooled areas after a fall rainstorm.

Trapping in Guaje Canyon occurred in late July 2002 (summer session) and in early November 2002 (fall session). During the summer session day temperatures were warm with highs in the 80’s with intermittent rainstorms in the afternoon. During the fall trapping session in Guaje Canyon day temperatures were in the 40’s to 50’s with nighttime temperatures dropping into the 20’s and 30’s. During the fall, rain occurred during the afternoon as well as during the late evening and through parts of the night.

Small Mammal Population Trapping and Characterization

For trapping in Pueblo, Guaje, and LA Canyons we used two rectangular grids in each canyon for each sampling period. In Pueblo Canyon, the western and central grids were used in the fall and the central and eastern grids were used in the summer. Grids in the same canyon were separated by a minimum of 100 m. Each grid was configured with five trap lines and 20 trap stations per line (total of 100 traps per grid). Each trap station consisted of one Sherman trap (live trap). Sherman traps were selected because of their suitability for trapping target species. Target species included all genera of Peromyscus, Neotoma, and Reithrodontomys. These genera were selected based on probability of presence within all study locations. The part of Acid Canyon designated for trapping was too short and narrow to contain grids of the dimensions used at the other sites, so it contained three lines of 20 traps for the northern grid and two lines for the southern grid (total of 60 and 40 traps per grid, respectively). Each trap was placed at 10-m intervals in all canyons. The trap lines followed the lay of the land using the stream channel as a baseline (Figures 5 and 6).

Figure 5. Sherman traps spaced at 10-m intervals in Guaje Canyon.

Figure 6. Traps placed next to the streambed in Guaje Canyon.

Trapping at each site extended over four nights. In the late afternoon, Sherman traps were opened and baited. Bait was a mixture of peanut butter and sweet feed (molasses-coated horse feed). The traps were checked early the following morning. Traps that had not been tripped by animals were then closed and all tripped traps were collected for animal processing (Figure 7). Animals collected on nights one through three during summer trapping were weighed and measured (body length, tail length, hind foot length, and ear length). The sex and species were determined, and reproductive status was recorded and the trap number noted. The animals were also ear tagged (#FF ear tag) and then released. We recorded only ear tag number and trap number on all recaptured animals. Animals captured on the fourth night were collected for possible laboratory contaminant analysis, because target species are known to be potential carriers of various strains of the Hantavirus, which may cause disease in humans.

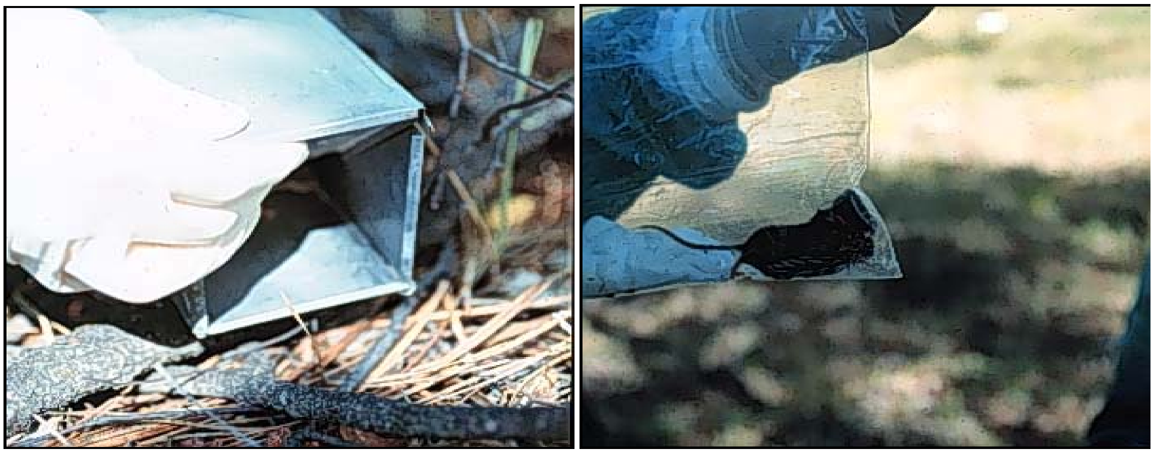


Figure 7. A Sherman trap (left) and a deer mouse placed in a plastic bag for processing.

During summer sampling, we obtained blood samples (from the interorbital region) for Hantavirus screening from the deer mouse (*Peromyscus maniculatus;* PEMA), brush mouse (*Peromyscus boylii;* PEBO), western harvest mouse (*Reithrodontomys megalotis;* REME), Mexican wood rat (*Neotoma mexicana;* NEME), pinyon mouse *(Peromyscus truei;* PETR), and white-throated wood rat (*Neotoma albigula;* NEAL). In the fall we obtained blood samples from deer mouse, brush mouse, western harvest mouse, Mexican wood rat, and white-throated wood rat for Hantavirus screening. All other species were released after capture because of either insufficient numbers or not being a target species.

Hantavirus screening was performed by the Medical School at the University of New Mexico. All target species captured from the fourth night of the summer trapping sessions were euthanized. Due to the low capture rate for fall sampling, all target species captured were euthanized from each trapping night. All data from animals captured were used for determining population characteristics. Only animals that screened negative for Hantavirus were considered for contaminant analysis for the protection of personnel performing contaminant analysis.

Density

Densities were estimated using Leslie's regression method (Serber 1982) applied to each grid where total numbers of new captures for each day were plotted against the cumulative daily captures. Confidence intervals were calculated at 95% using the general method

(Serber 1982). Mean percent daily captures rates for each canyon were calculated and compared to 1992–1994 data where similar sites were trapped (Ecology Group Small Mammal Database). Because of the low capture rates in the summer and some daily mortality, density could not be estimated using the program CAPTURE (White et al. 1982). The assumption of a closed population was violated by incidental trap mortality; therefore, a Leslie's regression was used.

Other Measures

Species composition and first-order diversity (species diversity) using Shannon-Weaver method (Hair 1980) were determined for each canyon for each season. Species diversity measures the variety of species and their proportions. In addition, comparison of sex ratios, reproductive stages, and mean body weights were made. Because of low capture rates, statistical analyses were performed only on sex ratios and body weights.

A Chi-square analysis was used to look at differences in sex ratios of species in each canyon during each sampling period (Zar 1984; SAS 1988). For the Chi-square, an assumption of equal proportional distribution of males to females was made. We used an alpha level of 0.05.

A parametric analysis of variance (AOV) was used to look at differences (alpha = 0.05) in adult weights by canyon and season (weights were normally distributed). However, because sample size was not balanced between the canyons, a general linear model (GLM) was used to conduct the AOV (SAS 1988; Zar 1984; Beitinger 1988). A Tukey Multiple Range Test (MRT) was used to detect where the differences occurred. A Tukey MRT was chosen for its ability to handle an unbalanced design and because it is less likely to result in a Type I error than other MRTs (Zar 1984).

RESULTS

Species Composition

Summer, Acid Canyon

Five deer mice were captured in Acid Canyon, and 13 deer mice were captured at the reference site in Guaje Canyon. Twenty-three brush mice were captured in Acid Canyon and 14 in Gauje Canyon. Mexican wood rat (n = 1), pinyon mouse (n = 1) and western harvest mouse (n = 6) were captured only in Acid Canyon. Silky pocket mouse (*Perognathus flavus;* PEFL [n = 8]) was captured only in Gauje Canyon (Figure 8).

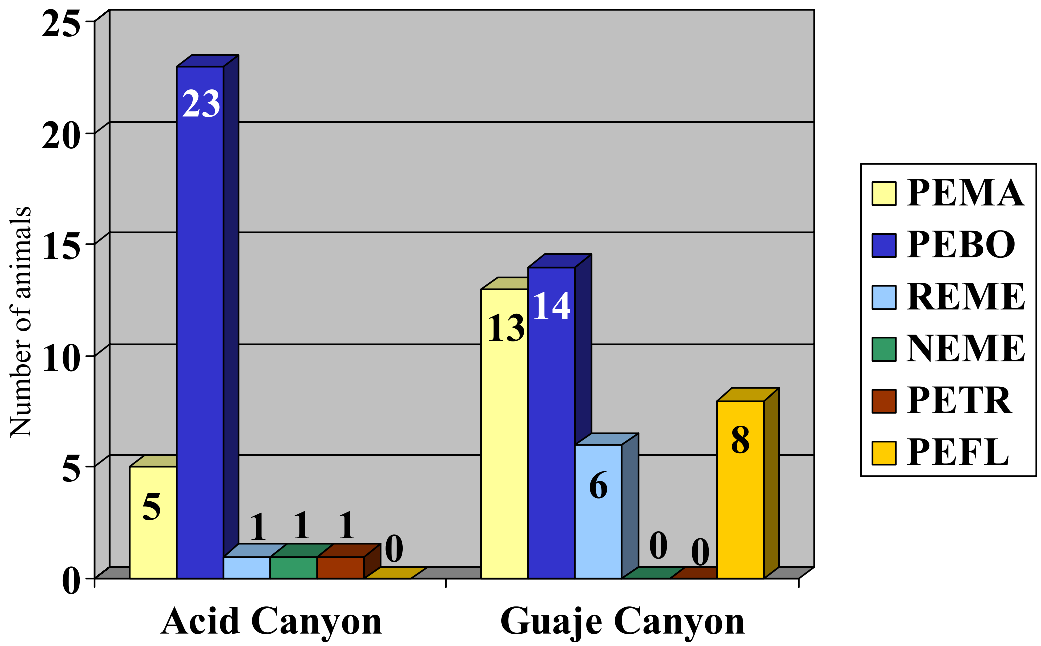


Figure 8. Species captured in Acid Canyon and Guaje Canyon in the summer.

Fall, Acid Canyon

Less than half as many brush mice were captured in Acid Canyon (n = 6) than were captured in the reference canyon, Guaje Canyon (n = 13), but similar numbers of deer mice were captured between Acid Canyon (n = 10) and Guaje Canyon (n = 14). Pinyon mice were only captured in Acid Canyon (n = 1) and only western harvest mouse (n = 1) and silky pocket mouse (n = 1) were captured in Guaje Canyon. Ten deer mice were captured compared to five in the summer, and a much lower number of brush mice were captured in the fall compared to the summer in Acid Canyon (6 vs 23 [Fig. 9]).

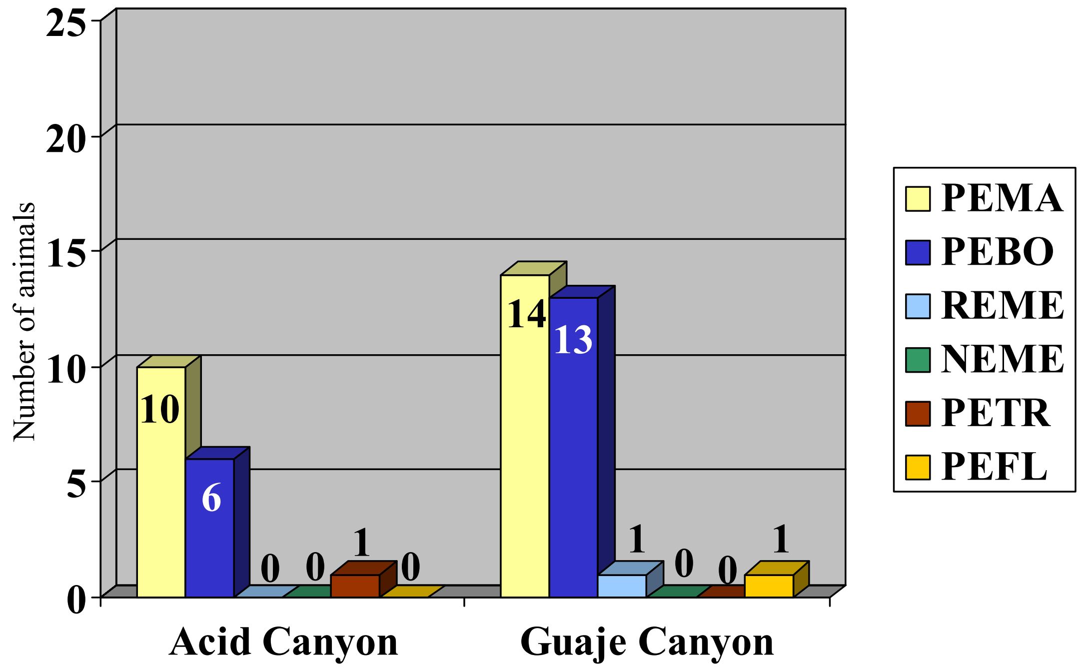


Figure 9. Species captured in Acid Canyon and Guaje Canyon in the fall.

Summer, LA Canyon

Thirteen deer mice were captured in both LA and Guaje Canyons. Nine brush mice were captured in LA Canyon and 14 in Guaje Canyon. Pinyon mice (n = 6) were captured in LA Canyon, but none were captured in Guaje Canyon, while silky pocket mice (n = 8) and western harvest mice (n = 6) were captured only in Guaje Canyon (Figure 10).

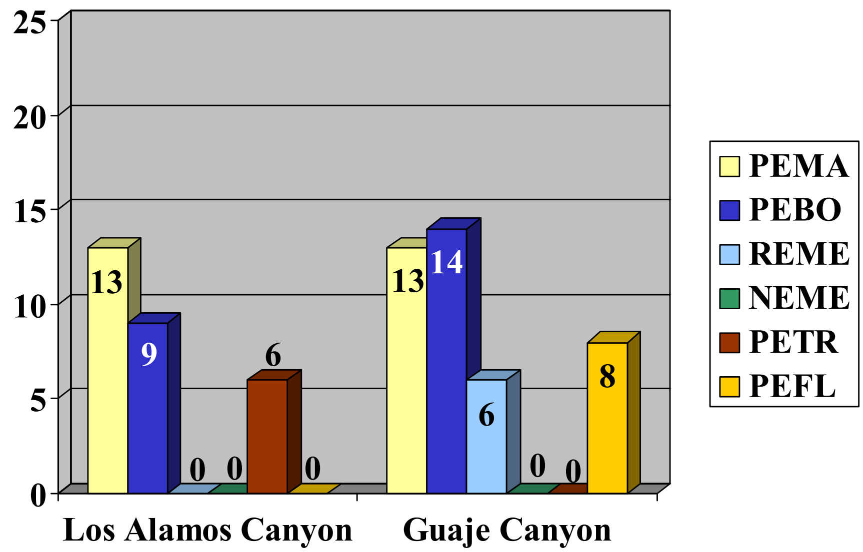


Figure 10. Species captured in LA Canyon and Guaje Canyon in the summer.

Fall, LA Canyon

One deer mouse was captured in LA Canyon, while 14 were captured in Guaje Canyon. Both LA and Guaje Canyons had similar captures for the pinyon mice (15 vs 13). One silky pocket mouse and one western harvest mouse were captured only in Guaje Canyon (Figure 11). A larger number of deer mice were captured in the summer compared to the fall (13 vs. 1), but more brush mice were captured in the fall within LA Canyon (9 vs 15).

Summer, Pueblo Canyon

Twenty-four deer mice were captured in Pueblo Canyon and 13 were captured in Guaje Canyon. Six brush mice were captured in Pueblo Canyon and 14 were captured in Guaje Canyon. Some species were captured only in Pueblo Canyon and not captured in Guaje Canyon (pinyon mouse {n = 14], Mexican wood rat [n = 1], and white-throated wood rat [n = 1]), while silky pocket mouse (n = 8) and western harvest mouse (n = 6) were only captured in Guaje Canyon (Figure 12).

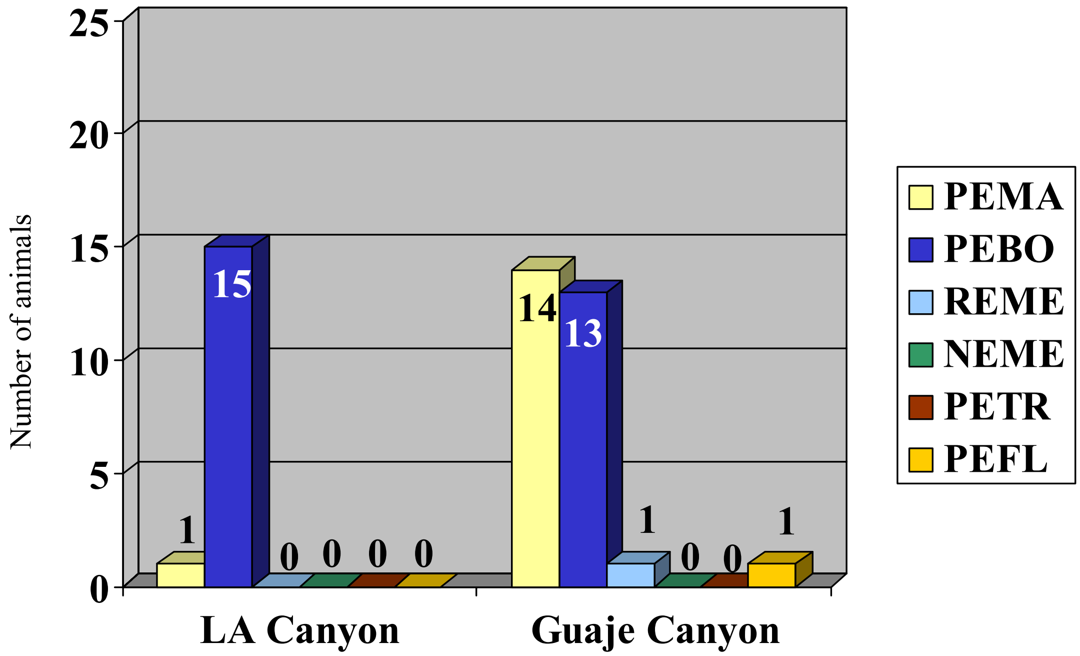


Figure 11. Species captured in LA Canyon and Guaje Canyon in the fall.

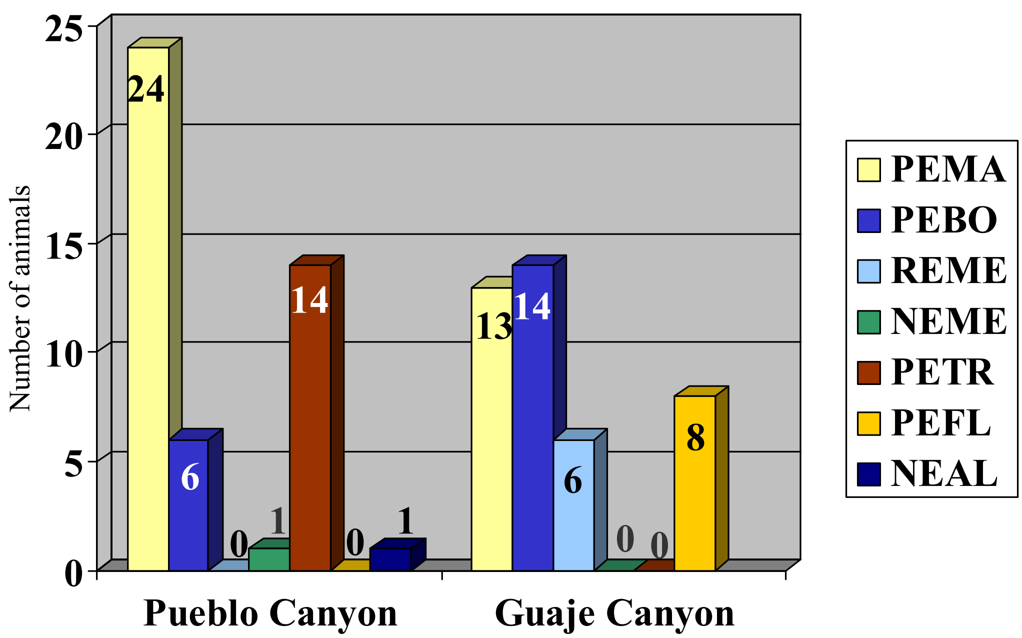


Figure 12. Species captured in Pueblo Canyon and Guaje Canyon in the summer.

Fall, Pueblo Canyon

Twelve deer mice were captured in Pueblo Canyon and 14 were captured in Guaje Canyon (Figure 13). A similar number of brush mice were captured in Pueblo Canyon (n = 10) and Guaje Canyon (n = 13). Seven pinyon mice were captured in Pueblo Canyon and none were captured in Guaje Canyon. A small number of western harvest mice were captured in both Pueblo and Guaje Canyons (2 vs 1). A silky pocket mouse was captured in Guaje Canyon and none in Pueblo Canyon. A larger number of deer mice (n = 25) were captured in the summer compared to the fall (n = 12), but more brush mice were captured in the fall (10 vs 6) within Pueblo Canyon than in the summer.

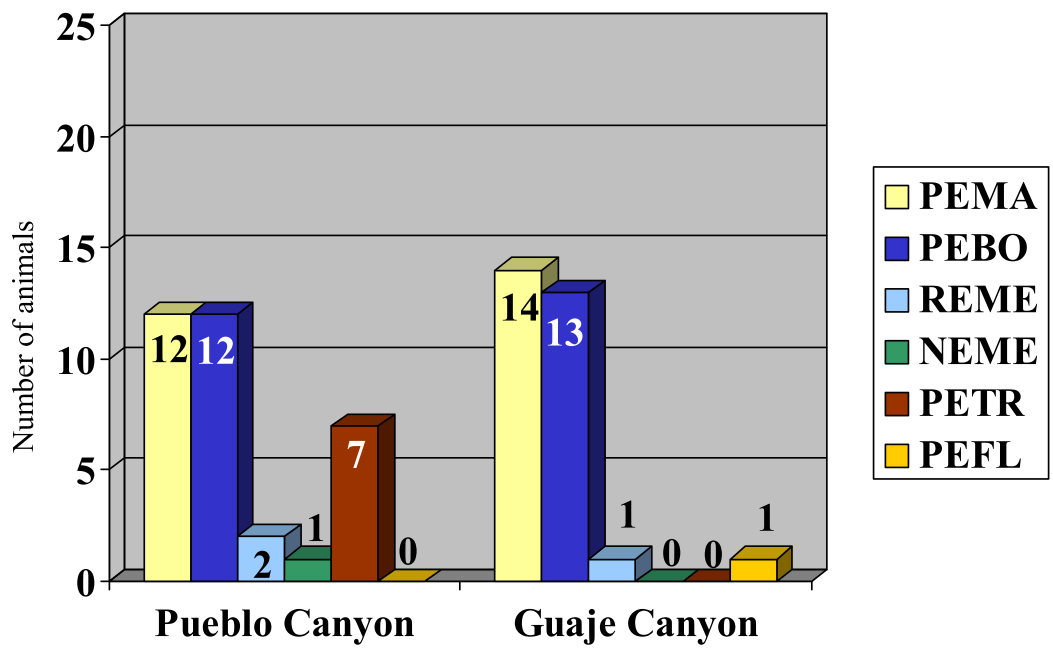


Figure 13. Species captured in Pueblo Canyon and Guaje Canyon in the fall.

Species Diversity

We calculated species diversity index (Hair 1980) for each canyon and for each season. The diversity index was based on the number of species from a possible seven different species captured. We also calculated the maximum theoretical diversity index for the canyons (seven species all with equal proportions).

Summer and Fall

During the summer, the diversity index ranged from 1.92 (Guaje Canyon) to 1.22 (Acid Canyon [Fig.14]). Maximum possible diversity index was 2.81. LA and Pueblo Canyons had very similar indices, 1.52 and 1.64, respectively.

During the fall, the diversity index ranged from 1.91 (Pueblo Canyon) to 0.34 (Los Alamos Canyon [Fig. 14]). There was no change in the diversity index calculated for Acid Canyon between fall (1.22) and summer (1.22). Guaje Canyon had a slight drop in diversity in the fall going from 1.92 (summer) to 1.62 (fall). Pueblo Canyon had a slight increase in diversity in the fall (1.64 to 1.91). LA Canyon had a large decrease in diversity during the fall. Diversity fell to 0.34 from a summer value of 1.22. Maximum possible diversity index remained at 2.8.

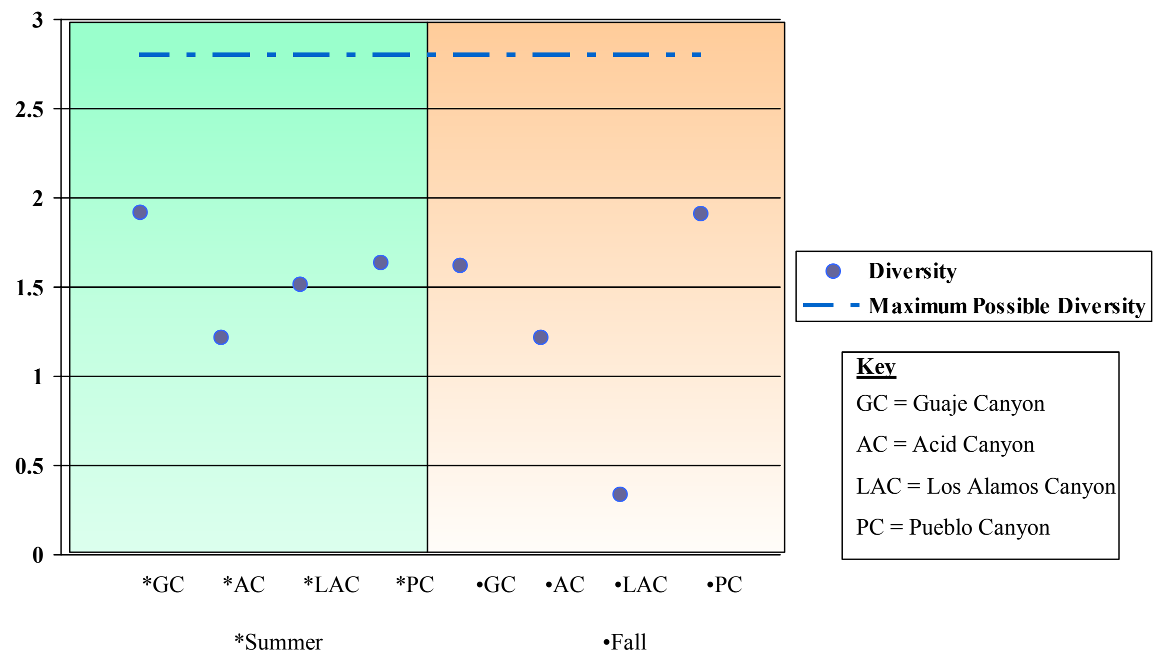


Figure 14. Species diversity indices for each canyon by season.

Sex Ratios

Sex ratios of adult males to females trapped within the same canyon and season were compared using a Chi-square (χ^2) analysis with an assumption of an equal distribution between the two sexes. The analysis was conducted for deer mice, brush mice, pinyon mice, and harvest mice where there was sufficient sample size. Statistical significance was determined at the alpha 0.05 level.

Acid Canyon, Summer

During the summer in Acid Canyon, adult brush mice were found in equal proportions of male (n = 12) to females (n = 10 [$\chi^2 = 0.1818$, $p = 0.6698$]). Additionally, adult deer mice were also found in near equal proportions but sample size was small (males, n = 2; females, n = 1) rendering the Chi-square invalid. There were insufficient sample sizes of the other captured species in Acid Canyon to perform the analysis (Table 1 and Figure 15).

Acid Canyon, Fall

No species were captured in sufficient numbers to perform a Chi-square analysis. A valid Chi-square requires a minimum sample size of 10 when degrees of freedom equal one. (Table 1 and Figure 15).

Guaje Canyon, Summer

In the summer in Guaje Canyon, equal proportions of males and females were found in adult deer mice (males, n = 7; females, n = 3; $\chi^2 = 1.6$, $p = 0.2059$) and brush mice (males, n = 4; females, n = 9; $\chi^2 = 1.9231$, $p = 0.1655$). There were insufficient sample sizes of the other captured species in Guaje Canyon to perform the analysis (Table 1 and Figure 16).

Guaje Canyon, Fall

Chi-square analysis was conducted for only deer mice and brush mice. Pinyon and harvest mice were not captured during the fall in Guaje Canyon. There was a statistically unequal ($\chi^2 = 4.5714$, $p = 0.0325$) proportion of male (n = 11) to female (n = 3) adult deer mice captured in the fall in Guaje Canyon. However, a statistically equal proportion ($\chi^2 = 1.9231$, $p = 0.1655$) of adult males (n = 4) and females (n = 9) were capture (Table 1 and Figure 16).

Table 1. Chi-Square Values and Probability for Testing the Equal Proportions of Males to Females of Each Species in Each Canyon by Season [Chi-Square Value (Probability)]

Canyon	*Deer Mouse*	*Brush Mouse*	*Pinyon Mouse*	*Harvest Mouse*
Acid				
Summer	Insufficient sample size	0.1818 (0.6698)	Insufficient sample size	Insufficient sample size
Fall	0.4000 (0.5271)	Insufficient sample size	Insufficient sample size	None Captured
Guaje				
Summer	1.6000 (0.2059)	1.9231 (0.1655)	None Captured	Insufficient sample size
Fall	*4.5714 (0.0325)*	1.9231 (0.1655)	None Captured	None Captured
Los Alamos				
Summer	*3.0000 (0.0833)*	Insufficient sample size	Insufficient sample size	None Captured
Fall	Insufficient sample size	3.2667 (0.0707)	None Captured	None Captured
Pueblo				
Summer	*5.5556 (0.0184)*	Insufficient sample size	0.2857 (0.5930)	None Captured
Fall	0.0000 (1.0000)	*6.4000 (0.0114)*	Insufficient sample size	Insufficient sample size

Blue shaded cells with italicized text are statistically significant at the alpha = 0.05 level.

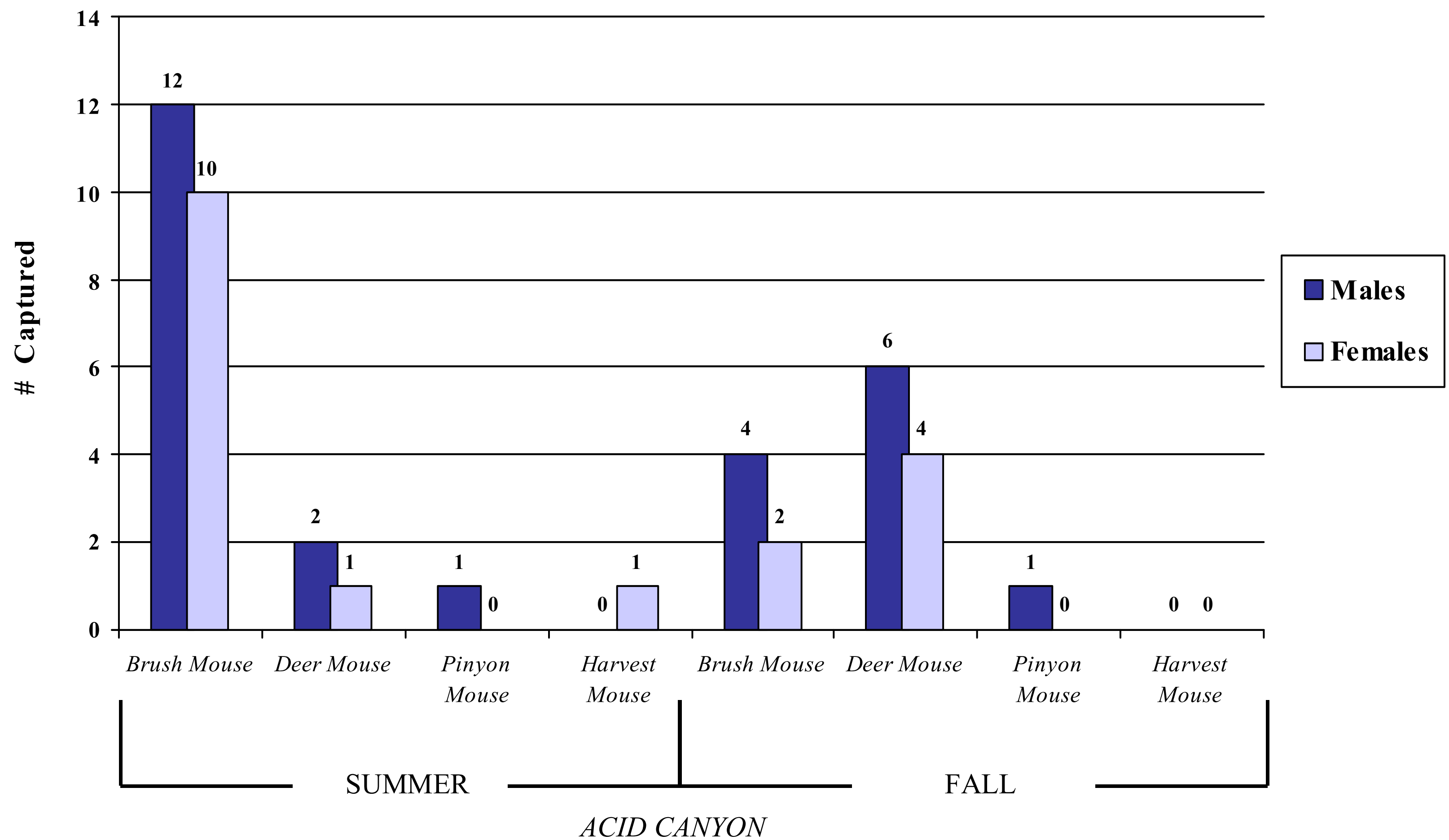


Figure 15. Males and females of each species captured during the summer and fall trapping sessions in Acid Canyon.

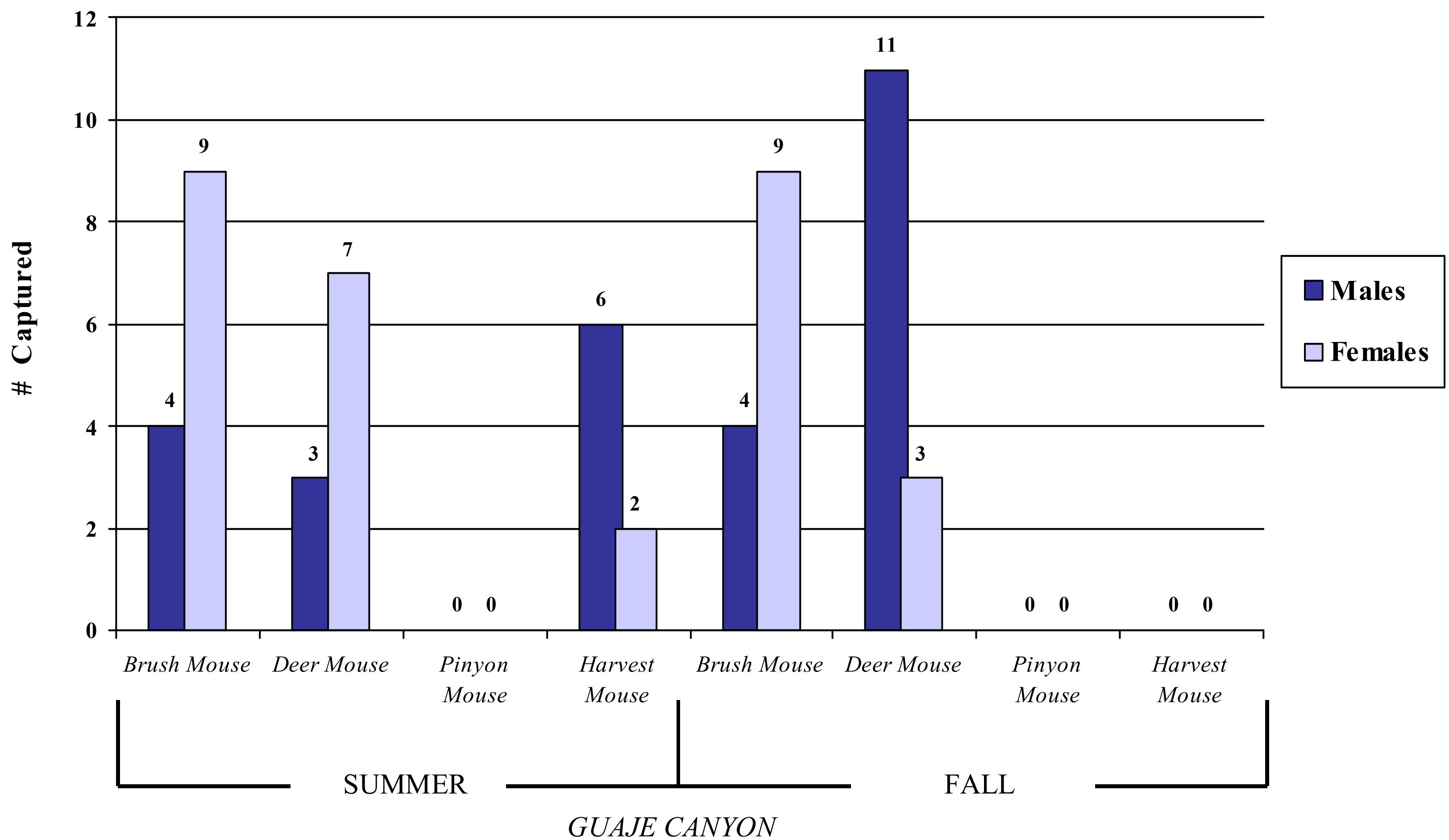


Figure 16. Males and females of each species captured during the summer and fall trapping sessions in Guaje Canyon.

LA Canyon, Summer

In the summer in Los Alamos Canyon, the proportion of adult male deer mice (n = 9) to adult females (n = 32) was found to be statistically equal ($\chi^2 = 3.0000$, $p = 0.0833$). There were insufficient sample sizes of the other captured species in LA Canyon to perform the analysis (Table 1 and Figure17).

LA Canyon, Fall

Brush mice were the only species captured in sufficient numbers to compare the distribution of males to females. We found a statistically equal distribution ($\chi^2 = 3.2667$, $p = 0.0707$) of adult male (n = 4) brush mice to adult female (n = 11) brush mice at the alpha = 0.05 level (Table 1 and Figure 17).

Pueblo Canyon, Summer

Adult deer mice captured during the summer in Pueblo Canyon were found to have an unequal distribution ($\chi^2 = 5.5556$, $p = 0.0184$) of males (n = 14) to females (n = 4). Pinyon mice were the only other species captured in sufficient numbers to perform the Chi-square analysis. Their distribution was not found to be statistically different (at the 0.05 level) than an equal proportional distribution ($\chi^2 = 0.2857$, $p = 0.5930$ [Table 1 and Figure 18]).

Pueblo Canyon, Fall

Chi-square analysis was not performed on harvest mice or pinyon mice captured in Pueblo Canyon because of insufficient sample size. However, Chi-square analysis was performed on the remainder of the species (Table 1). A statistically unequal distribution ($\chi^2 = 6.4000$, $p = 0.0114$) was found in adult male (n = 1) brush mice to adult female (n = 9) brush mice. An equal distribution ($\chi^2 = 0.0000$, $p = 1.0000$) of adult male deer mice (n = 6) to adult female deer mice (n = 6) was observed (Figure 18).

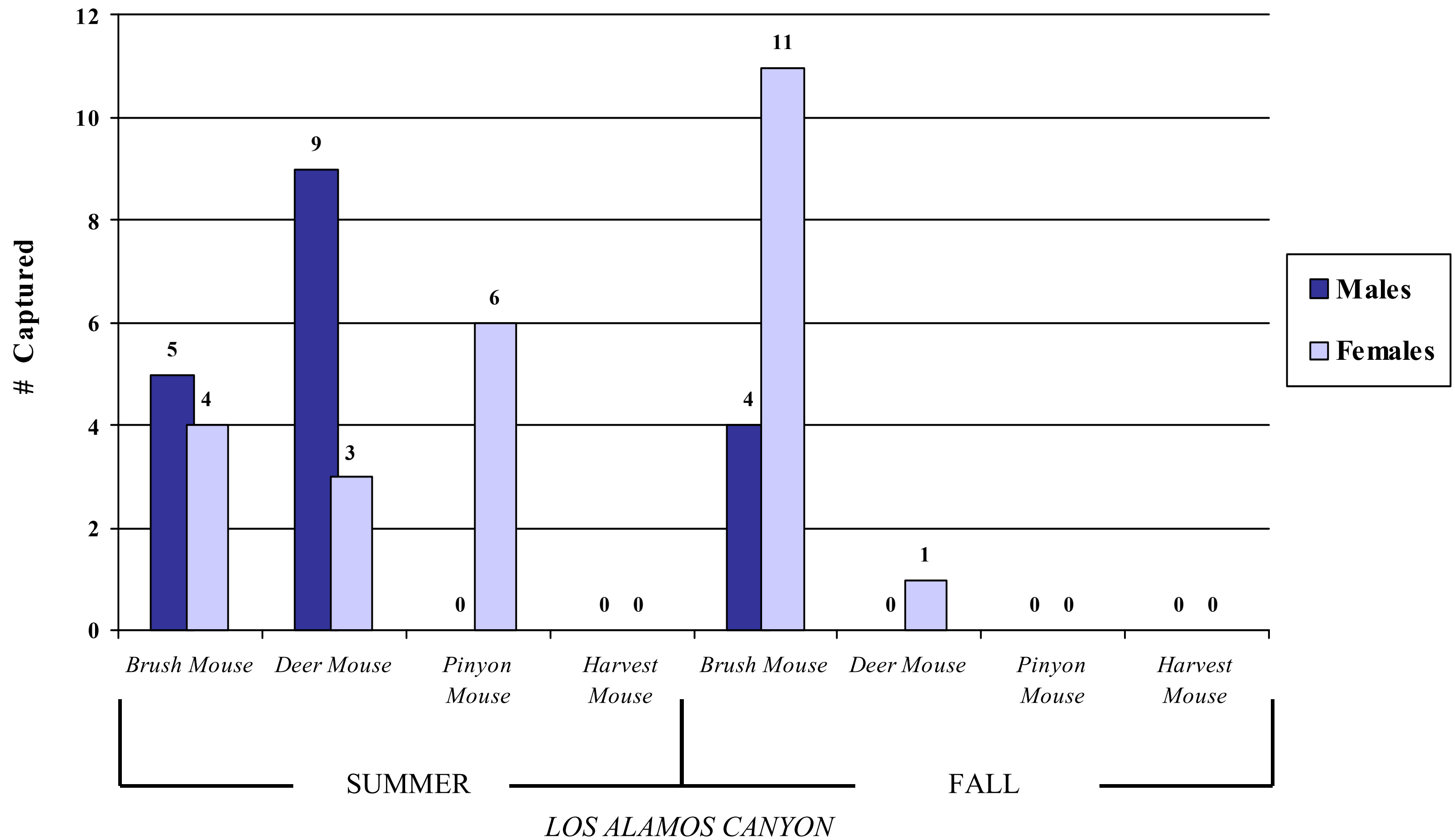


Figure 17. Males and females of each species captured during the summer and fall trapping sessions in LA Canyon.

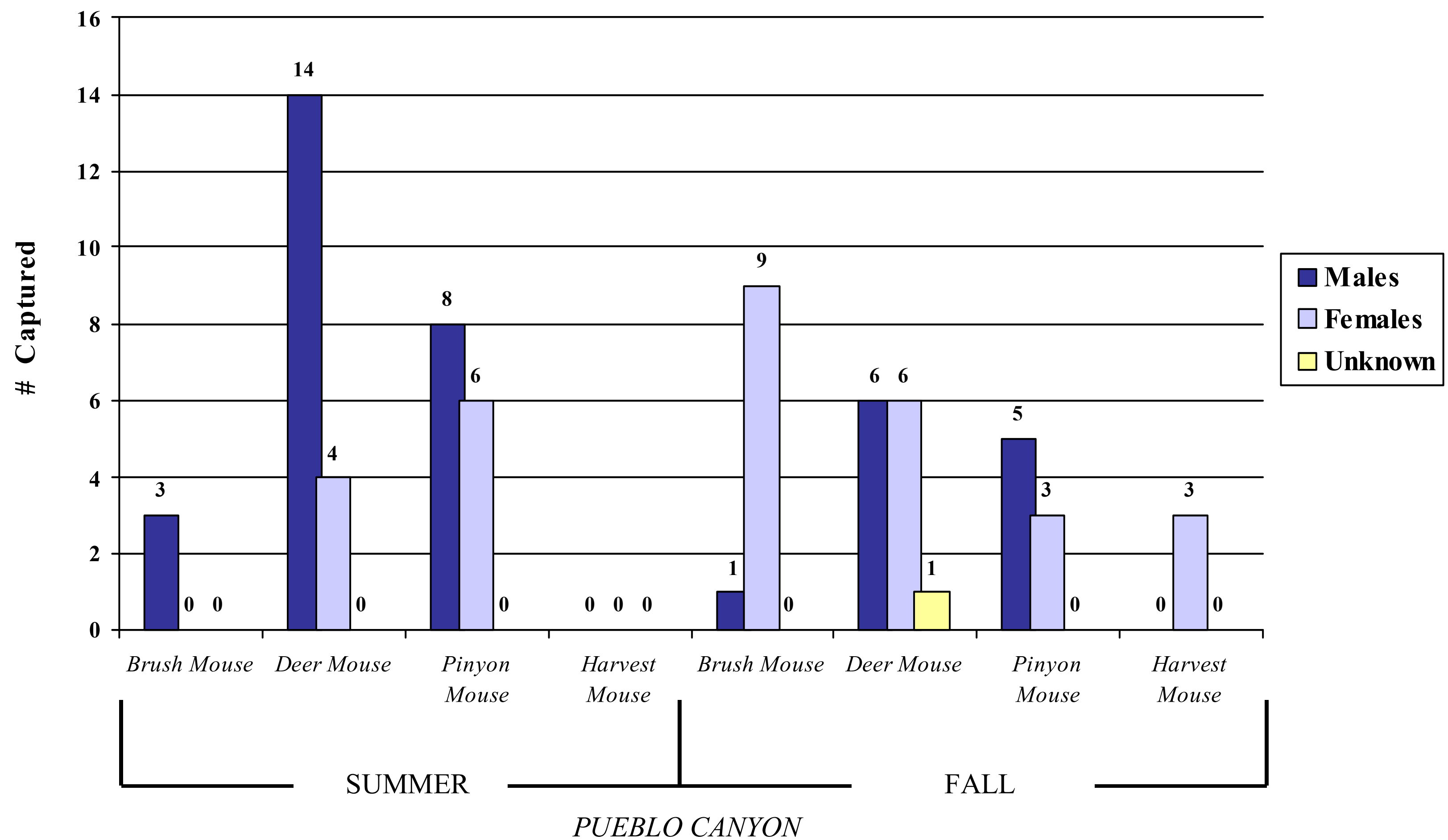


Figure 18. Males and females of each species captured during the summer and fall trapping sessions in Pueblo Canyon.

Reproductive Status

Summer, Female Brush Mice

All four reproductive categories (juveniles, lactating, non-reproductive [adults], and pregnant) of female brush mice were represented in the reference canyon, Guaje Canyon. Acid Canyon and LA Canyon had two of the four categories (non-reproductive adults and pregnant) with Acid Canyon having an equal proportion of non-reproductive females (n = 5) to pregnant females (n = 5). We captured only juvenile female brush mice (n = 3) during the summer in Pueblo Canyon (Table 2 and Figure 19).

Summer, Male Brush Mice

All three reproductive categories (juveniles, non-scrotal, and scrotal) of male brush mice were captured in Acid Canyon. In addition, we captured non-scrotal males in both LA and Pueblo Canyons and scrotal males in LA and Guaje Canyons. Juveniles were only captured in Acid Canyon (Table 2 and Figure 20).

Fall, Female Brush Mice

Adult non-reproductive females were captured in all four canyons and this was also the only category of female brush mice that were captured in Acid Canyon. All other canyons had representatives from at least two reproductive categories. Pregnant females were only captured in Guaje Canyon (n = 3) and juveniles (n = 1) were only captured in Pueblo Canyon. One lactating female was captured in both LA and Pueblo Canyons (Table 2 and Figure 21).

Fall, Male Brush Mice

We captured non-scrotal brush mice within all four canyons and this was the only category of males captured in LA and Acid Canyons. Juvenile males were only captured in Pueblo Canyon and scrotal males were only captured in Guaje Canyon (Table 2 and Figure 22).

Summer, Female Deer Mice

We captured non-reproductive adult female deer mice in all four canyons during the summer. In LA Canyon, non-reproductive female (n = 1) was the only category of females captured. One pregnant female was captured in both Pueblo and Guaje Canyons. We captured lactating females (n = 2) only in Pueblo Canyon (Table 3 and Figure 23).

Table 2. Male and Female Brush Mice Captured during Summer and Fall in all Four Canyons

	Acid Canyon	LA Canyon	Pueblo Canyon	Guaje Canyon
Summer				
Male				
Juveniles	1	0	0	0
Non-Scrotal	1	2	3	0
Scrotal	11	3	0	4
Females				
Juveniles	0	0	3	1
Lactating	0	0	0	2
Non-reproductive (adults)	5	1	0	3
Pregnant	5	3	0	4
Fall				
Male				
Juveniles	0	0	1	0
Non-Scrotal	4	4	1	2
Scrotal	0	0	0	2
Females				
Juveniles	0	0	1	0
Lactating	0	1	1	0
Non-reproductive (adults)	2	10	8	6
Pregnant	0	0	0	3

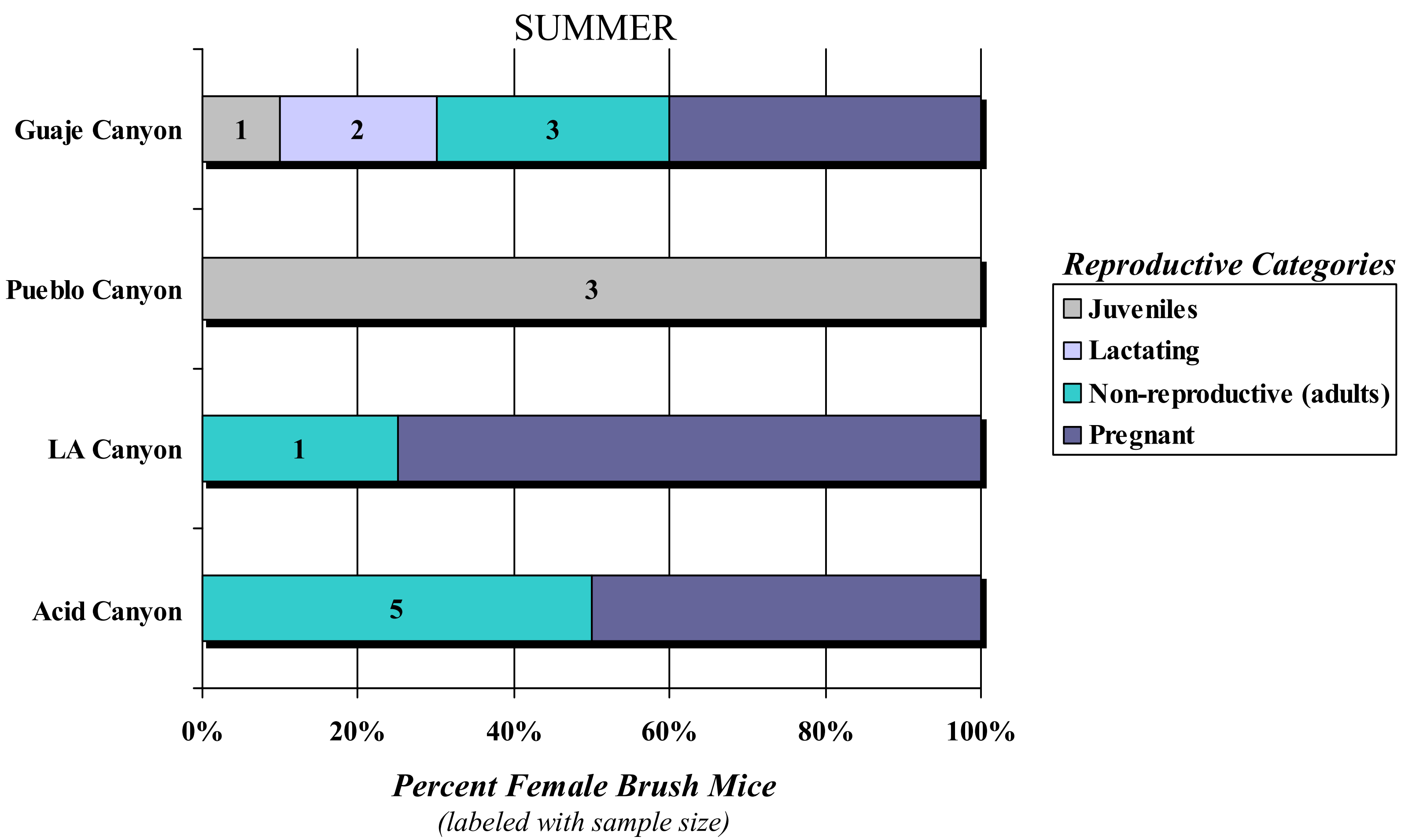


Figure 19. Reproductive status of female brush mice captured during the summer, 2002.

Table 3. Male and Female Deer Mice Captured during Summer and Fall in all Four Canyons

	Acid Canyon	LA Canyon	Pueblo Canyon	Guaje Canyon
Summer				
Male	0	0	0	0
Juveniles	1	1	1	0
Non-Scrotal	2	4	14	1
Scrotal	0	5	0	6
Females				
Juveniles	1	0	5	3
Lactating	0	0	0	0
Non-reproductive (adults)	1	2	3	2
Pregnant	0	1	1	1
Fall				
Male				
Juveniles	0	0	0	0
Non-Scrotal	6	0	6	11
Scrotal	0	0	0	0
Females				
Juveniles	0	0	0	0
Lactating	0	0	2	0
Non-reproductive (adults)	4	1	3	2
Pregnant	0	0	1	1

Reproductive category and sex was not identified for one deer mouse captured in Pueblo Canyon.

Summer, Male Deer Mice

LA Canyon had captures from all reproductive categories for male deer mice. Juveniles were captured in all canyons except Guaje Canyon. Non-scrotal males were not captured in Acid Canyon and scrotal males were not captured in Pueblo Canyon. Otherwise, scrotal and non-scrotal males were represented in the remainder of the canyons with Pueblo having a high number (n = 14) of non-scrotal males (Table 3 and Figure 24).

Fall, Female Deer Mice

During the fall, we captured non-reproductive female deer mice from all four canyons. One pregnant female was captured in each Pueblo and Guaje Canyons. Lactating females (n = 2) were only captured in Pueblo Canyon. We captured only non-reproductive females in Acid and LA Canyons (Table 3 and Figure 25).

Fall, Male Deer Mice

We did not capture any male deer mice in LA Canyon during the fall. For the remainder of the canyons only non-reproductive males were captured. One deer mouse was captured in Pueblo Canyon where the sex and reproductive status were not determined (Table 3 and Figure 26).

Summer, Female Pinyon Mice

Female pinyon mice were not captured in Guaje or Acid Canyons during the summer trapping session. We captured female pinyon mice from three of the four reproductive categories—adult non-reproductive, pregnant, and lactating—during the summer. LA Canyon had captures from non-reproductive and lactating categories and no juvenile female pinyon mice were captured in any of the four canyons during the summer trapping session (Table 4 and Figure 27)

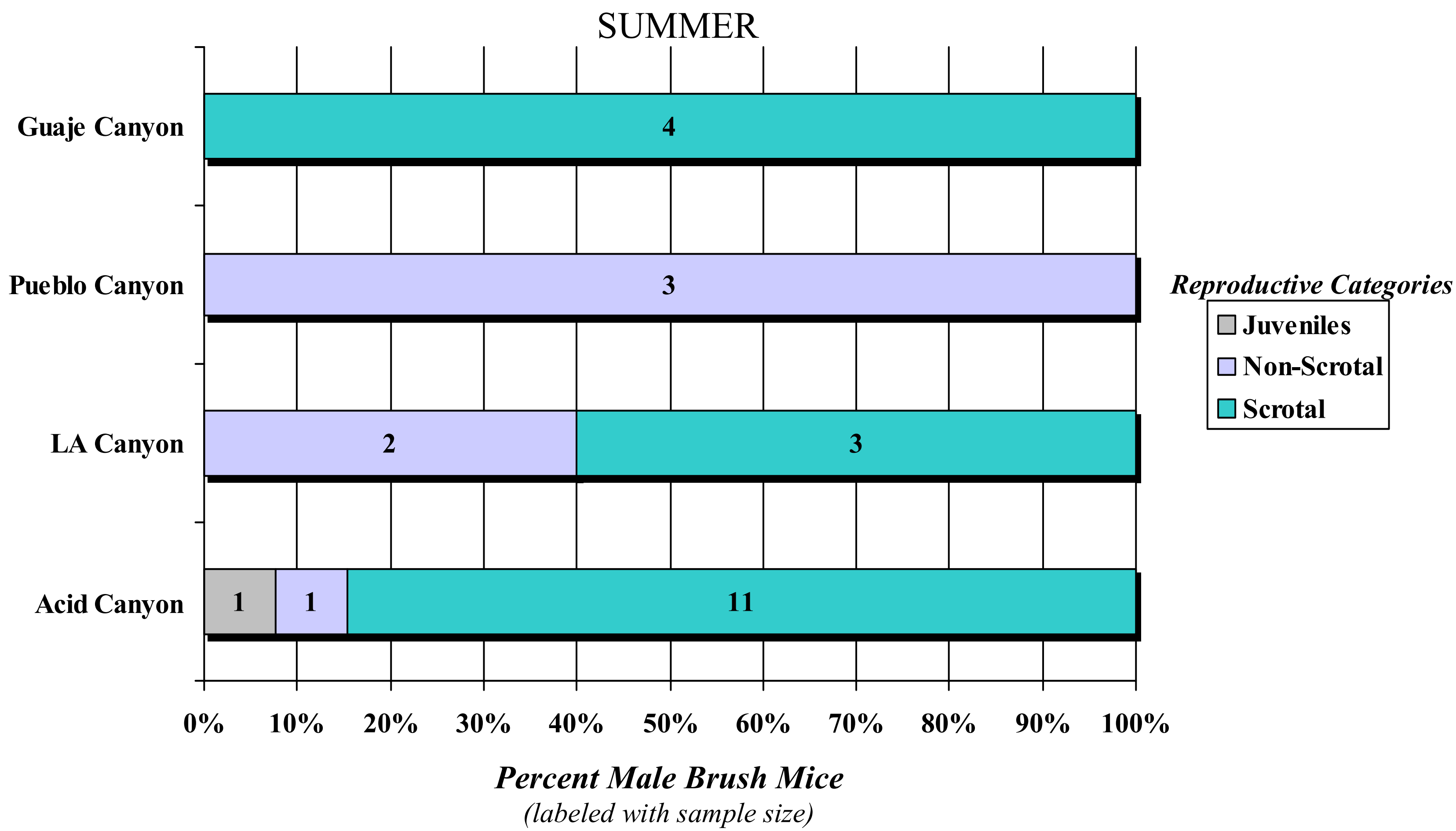


Figure 20. Reproductive status of male brush mice captured during the fall, 2002.

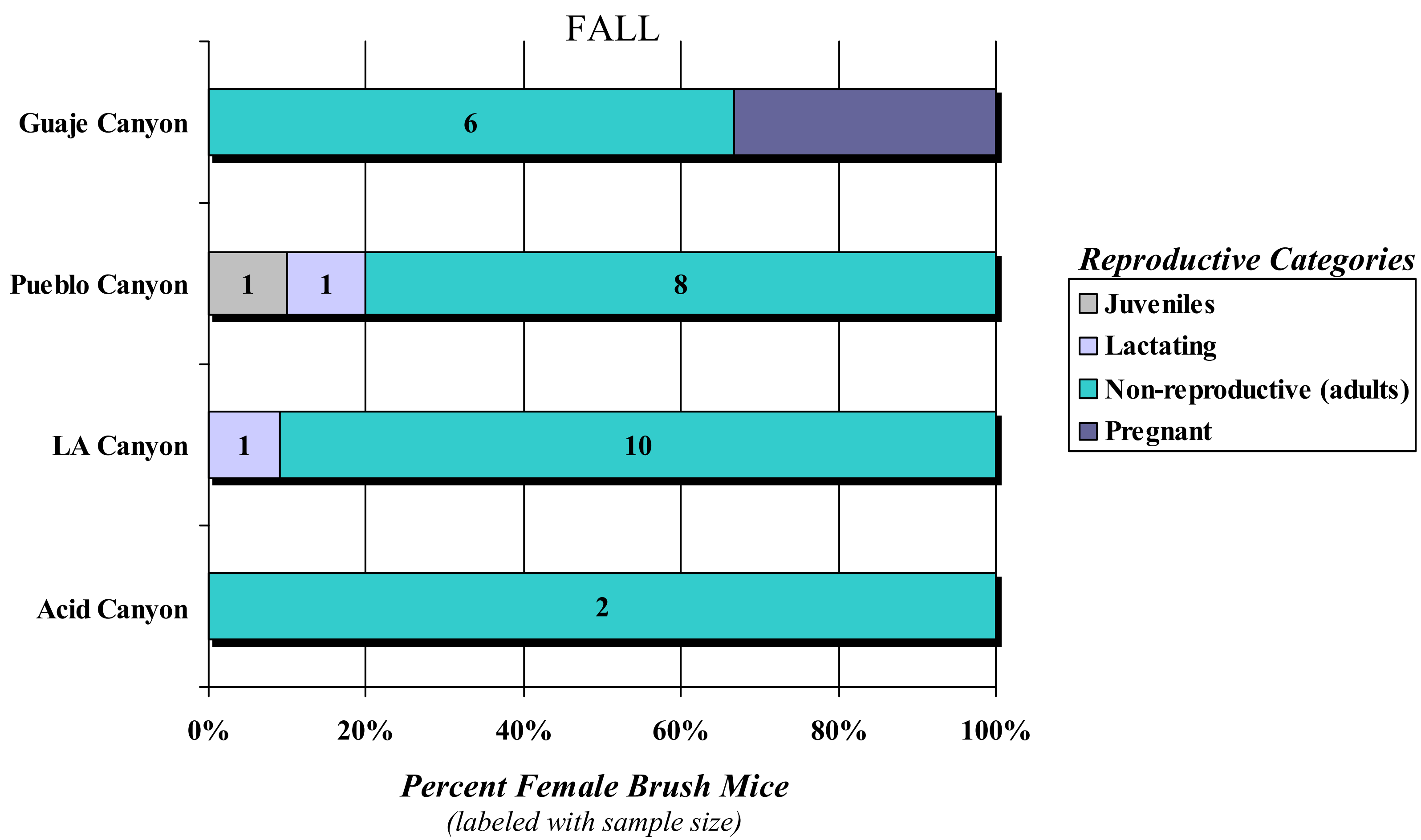


Figure 21. Reproductive status of female brush mice captured during the summer, 2002.

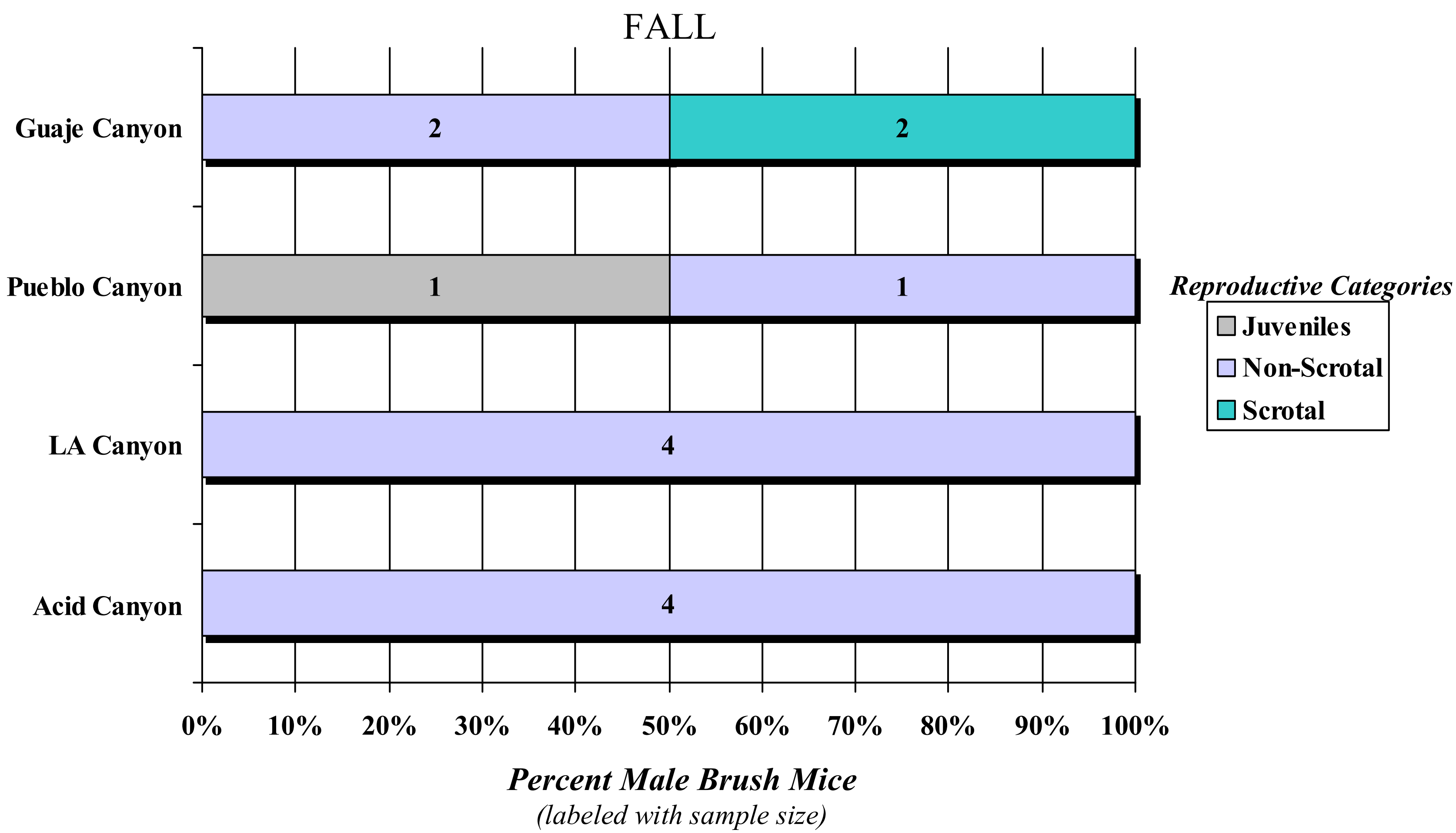


Figure 22. Reproductive status of male brush mice captured during the fall, 2002.

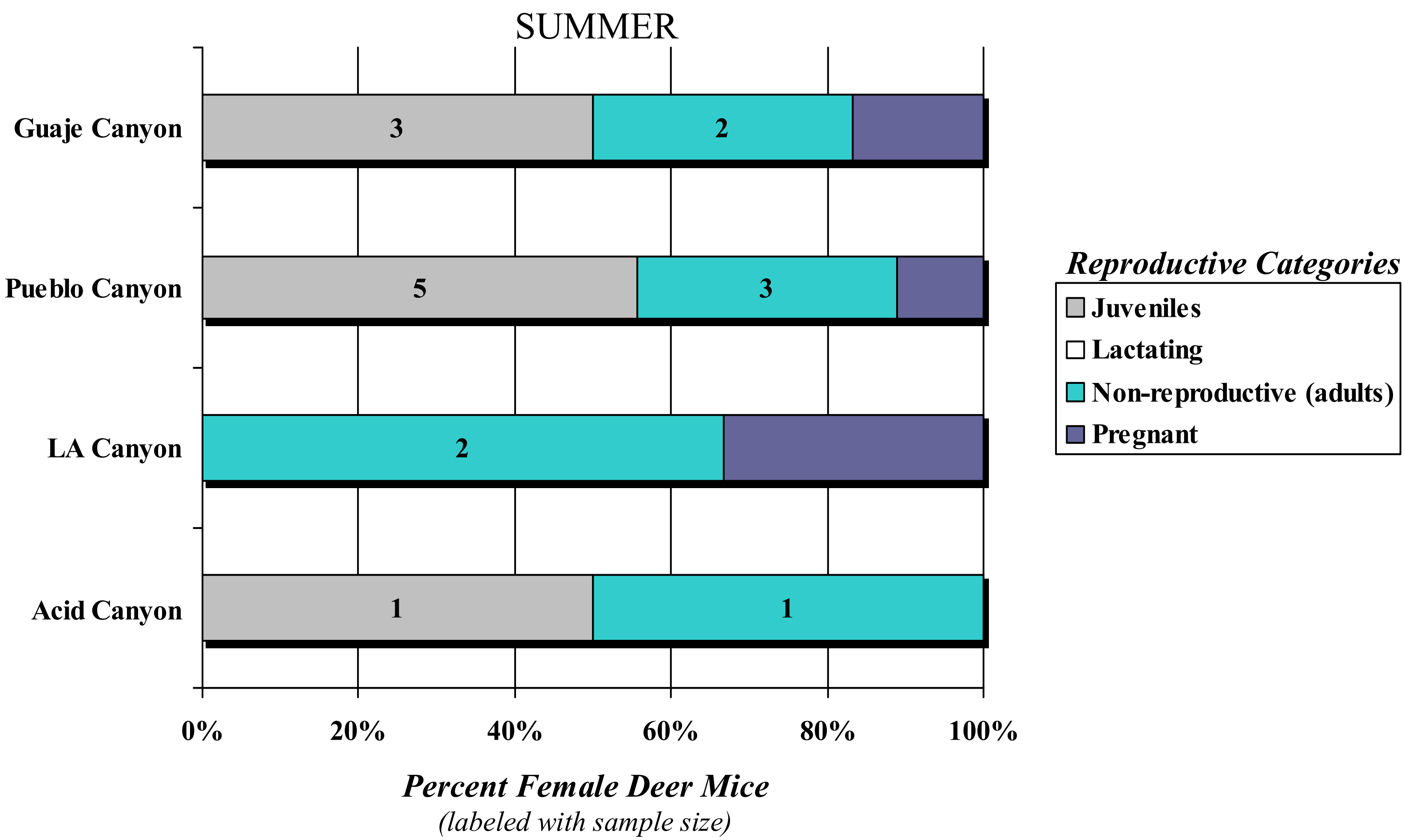


Figure 23. Reproductive status of female deer mice captured during the summer, 2002.

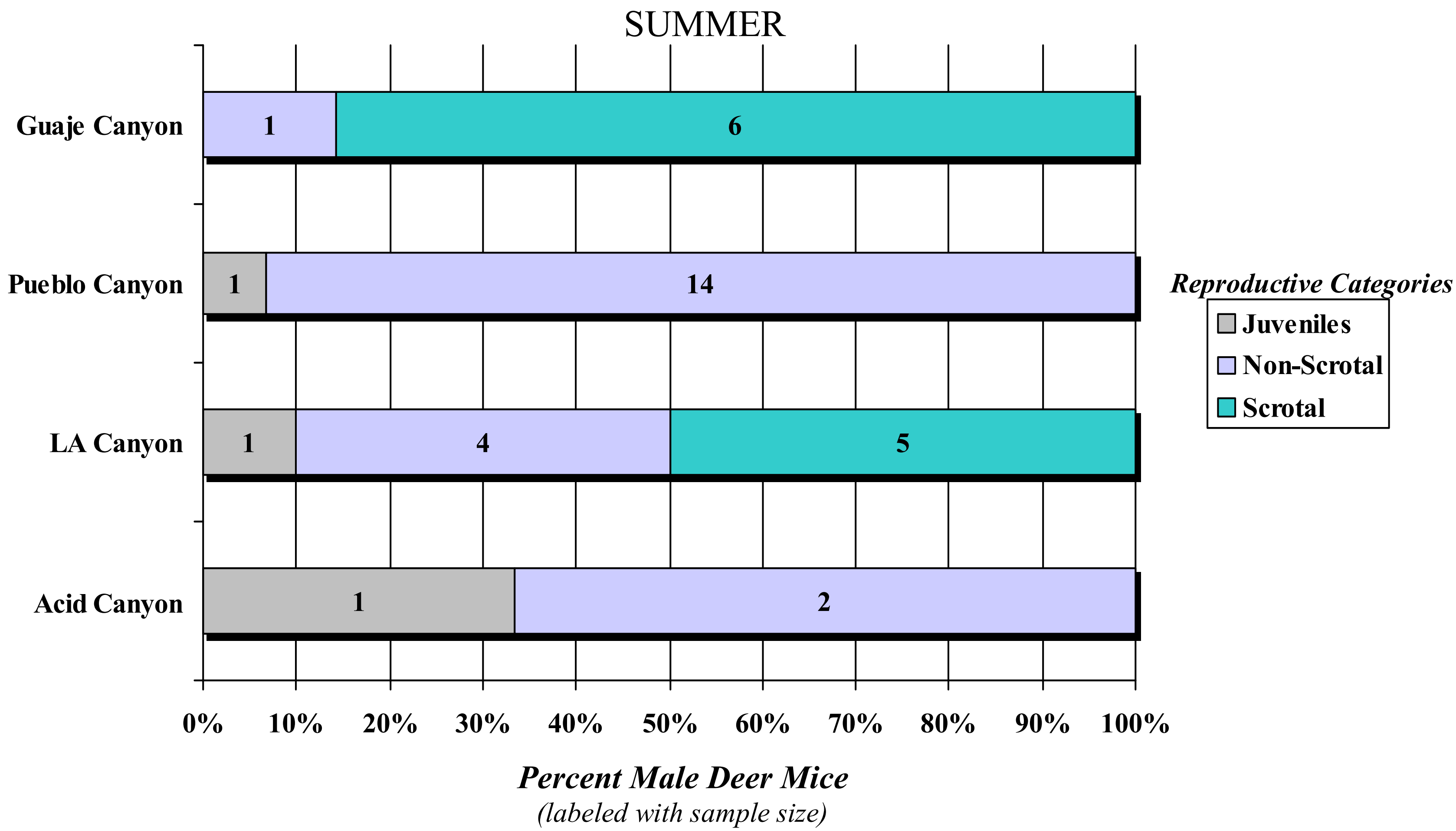


Figure 24. Reproductive status of male deer mice captured during the summer, 2002.

Table 4. Male and Female Pinyon Mice Captured during Summer and Fall in all Four Canyons

	Acid Canyon	LA Canyon	Pueblo Canyon	Guaje Canyon
Summer				
Male				
Juveniles	0	0	0	0
Non-Scrotal	0	0	5	0
Scrotal	1	0	3	0
Females				
Juveniles	0	0	0	0
Lactating	0	2	0	0
Non-reproductive (adults)	0	4	0	0
Pregnant	0	0	1	0
Fall				
Male				
Juveniles	0	0	0	0
Non-Scrotal	1	3	0	0
Scrotal	0	0	0	0
Females				
Juveniles	0	0	0	0
Lactating	0	0	1	0
Non-reproductive (adults)	0	0	4	0
Pregnant	0	0	0	0

Summer, Male Pinyon Mouse

Male pinyon mice were not captured in LA Canyon and Guaje Canyon during the summer trapping session. Only one scrotal male was captured in Acid Canyon. We captured both non-scrotal (n = 5) and scrotal (n = 3) males in Pueblo Canyon. Male juvenile pinyon mice were not captured in any of the four canyons (Figure 28 and Table 4).

Fall, Female Pinyon Mouse

Female pinyon mice were not captured in Acid, LA, and Guaje Canyons during the fall trapping session. Both lactating (n = 1) and non-reproductive (n = 4) females were captured in Pueblo Canyon (Figure 29 and Table 4).

Fall, Male Pinyon Mouse

We did not capture any male pinyon mice in LA or Guaje Canyons. One non-scrotal male was captured in Acid Canyon and three in Pueblo Canyon. Juvenile males were not captured in any canyon (Figure 30 and Table 4).

Weights

Because of low sample sizes, the statistical comparisons of adult female and male weights were only compared for deer mice and brush mice. In addition, there were insufficient sample sizes (n>3) in some groupings for a valid comparison. In these cases they were excluded from analysis. Table 5 shows the canyons that were included in the analysis, testing the null hypothesis: *there are no differences in adult rodent weights by sex, species, and season between the canyons.*

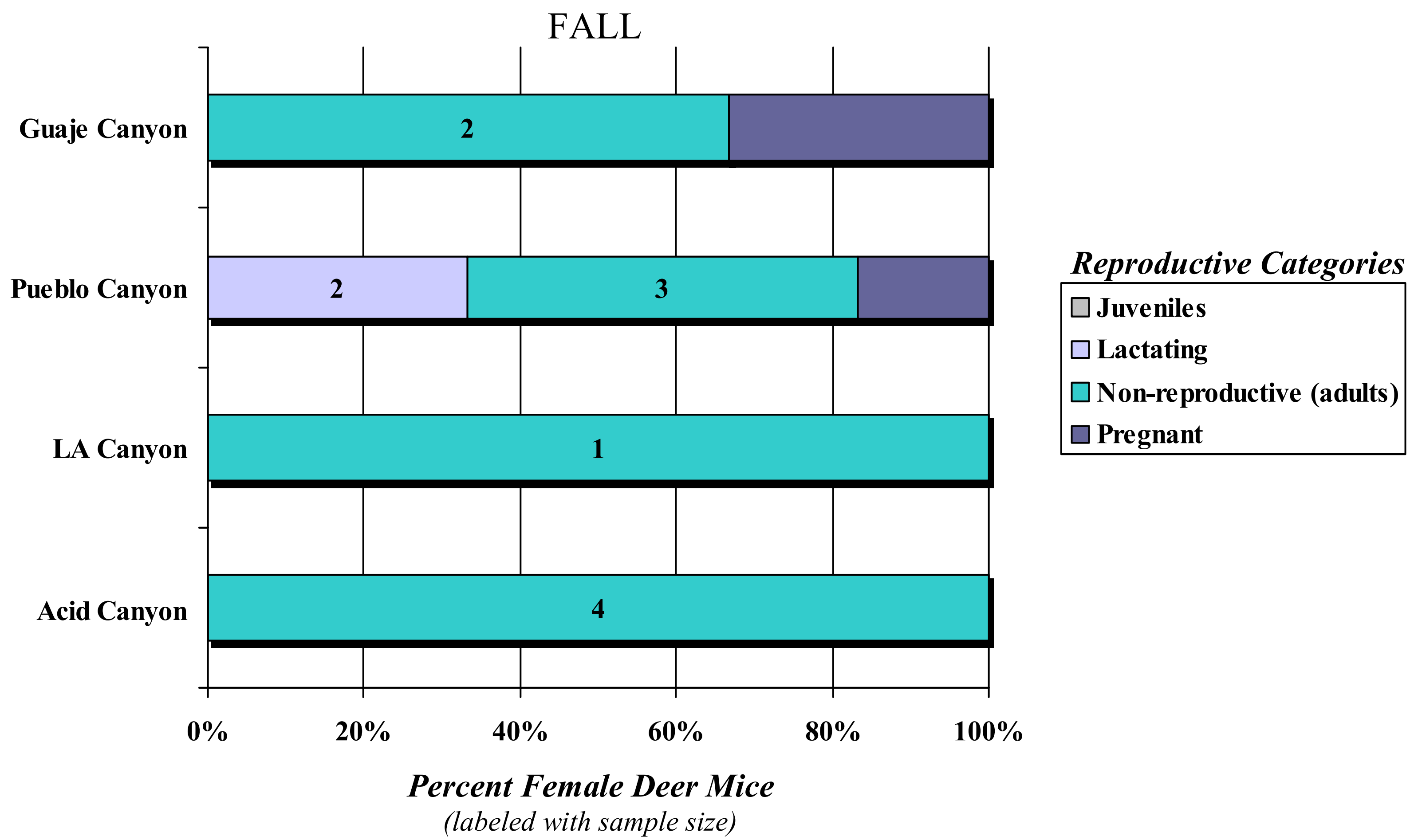


Figure 25. Reproductive status of female deer mice captured during the fall, 2002.

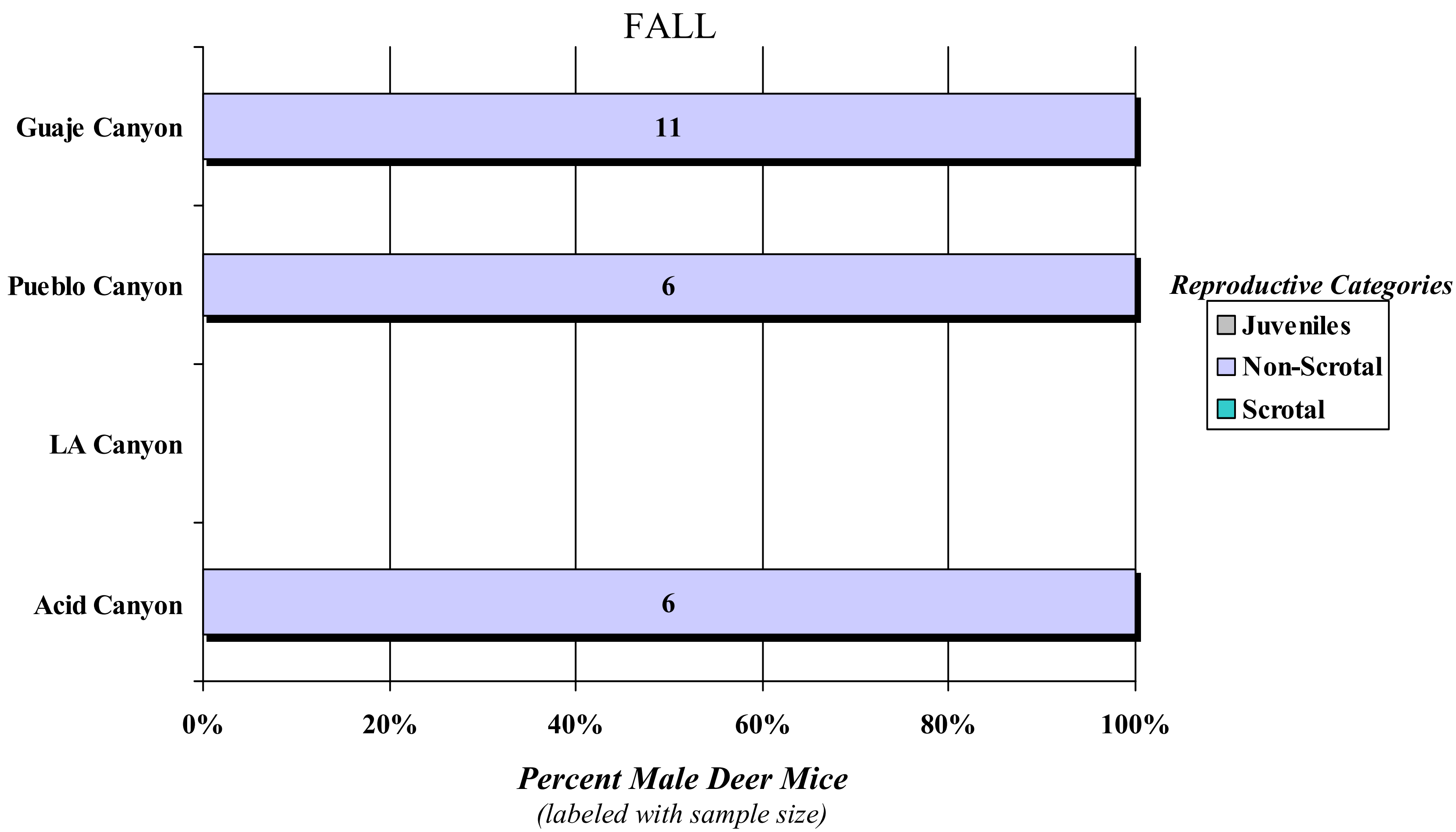


Figure 26. Reproductive status of male deer mice captured during the fall, 2002.

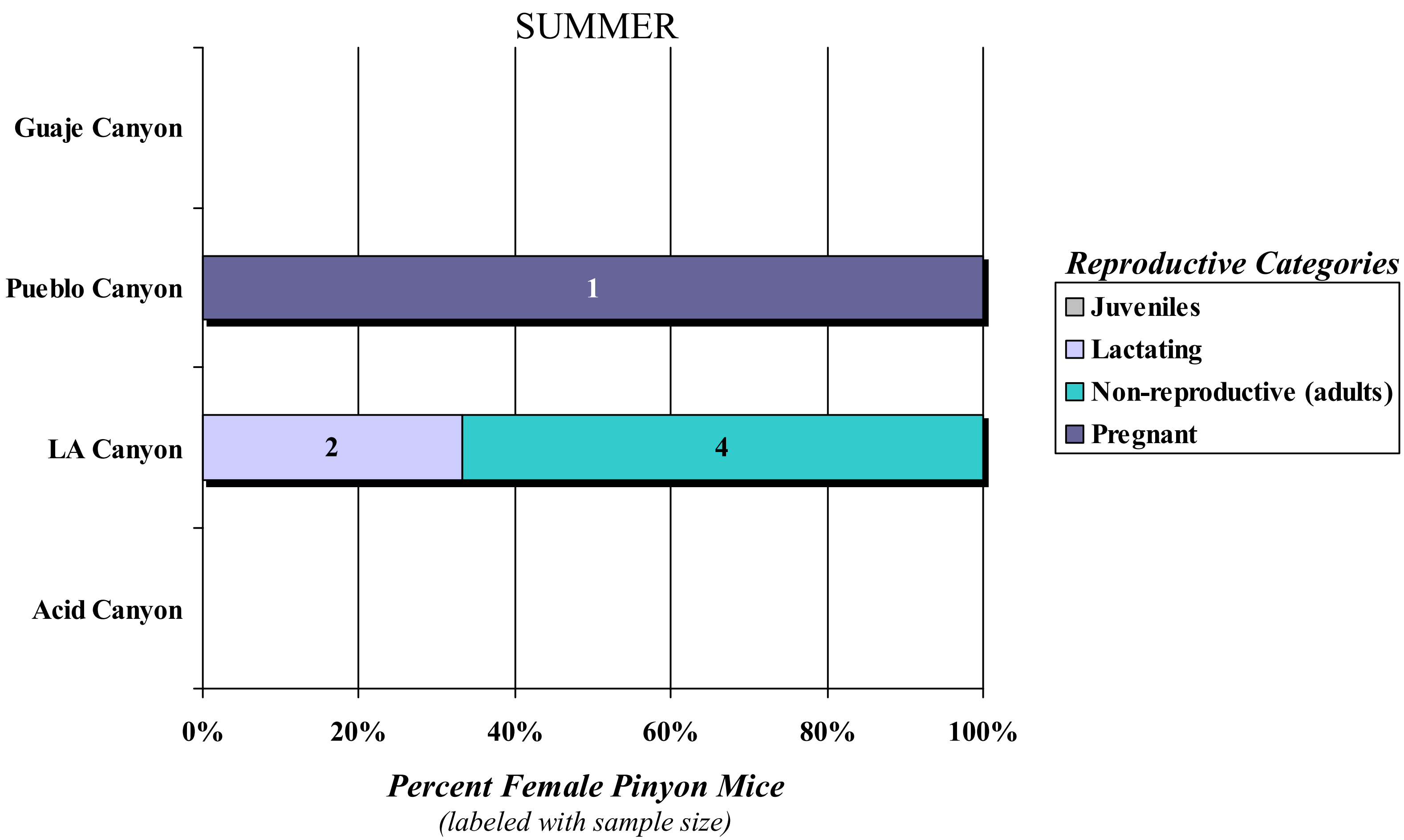


Figure 27. Reproductive status of female pinyon mice captured during the summer, 2002.

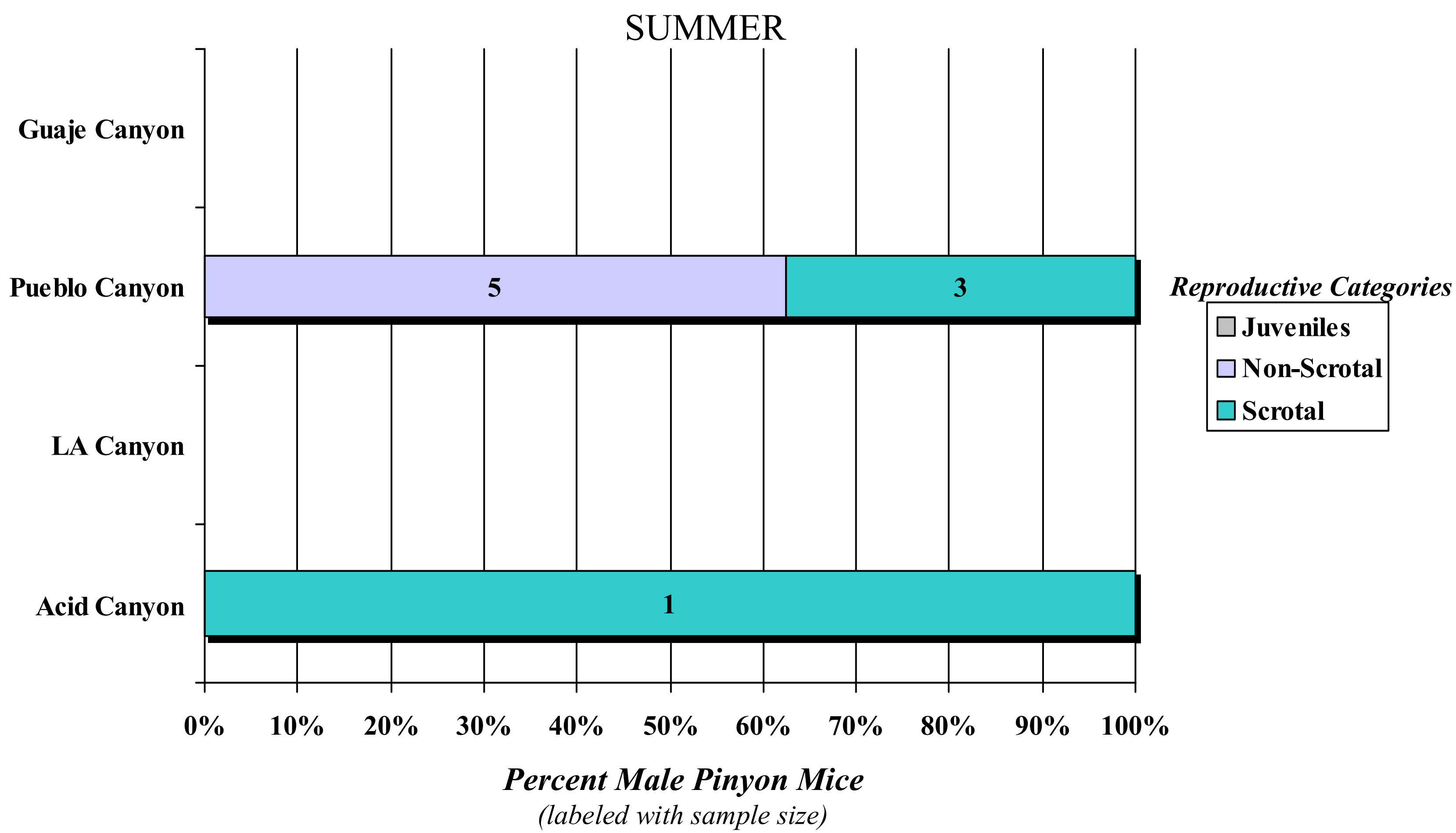


Figure 28. Reproductive status of male pinyon mice captured during the summer, 2002.

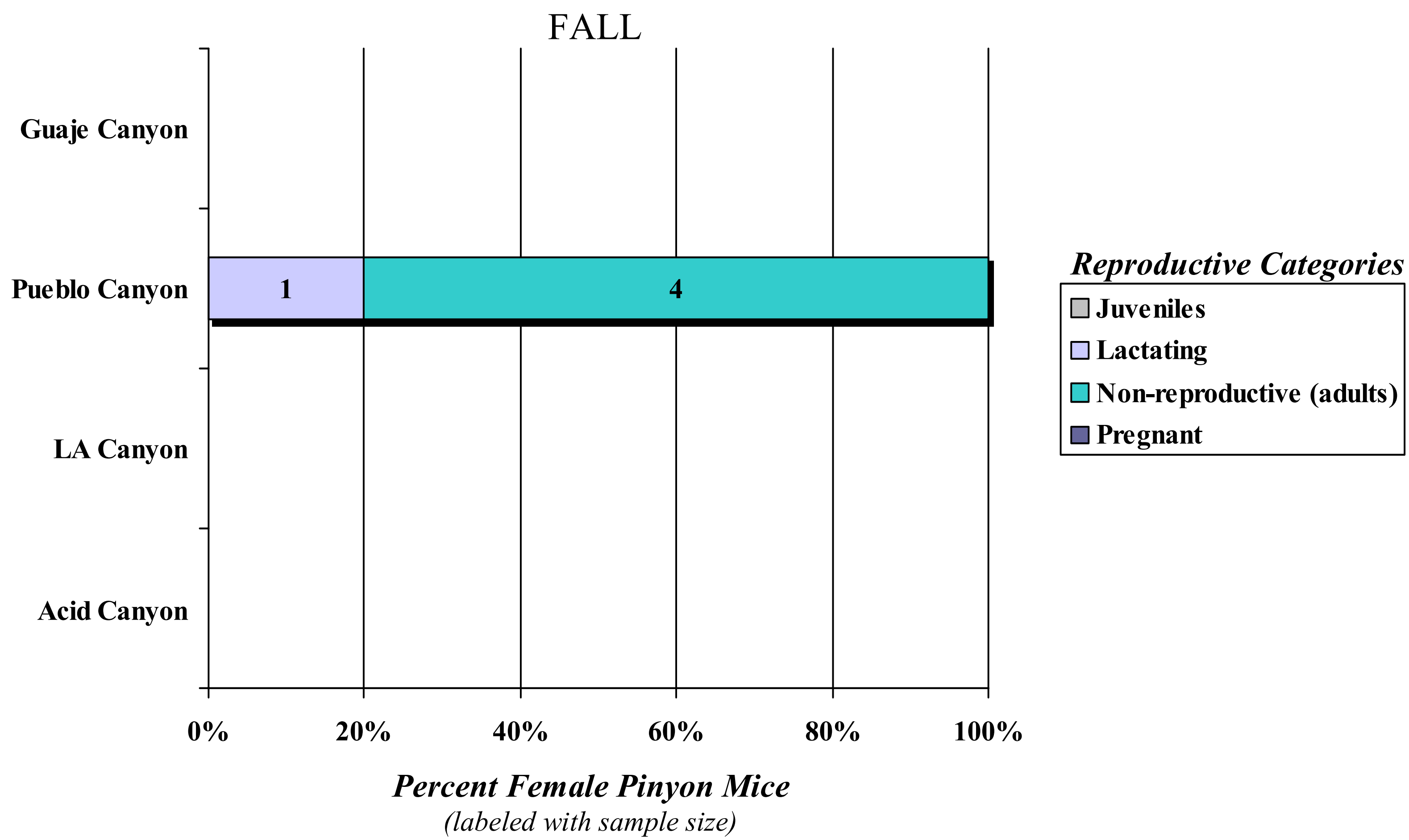


Figure 29. Reproductive status of female pinyon mice captured during the fall, 2002.

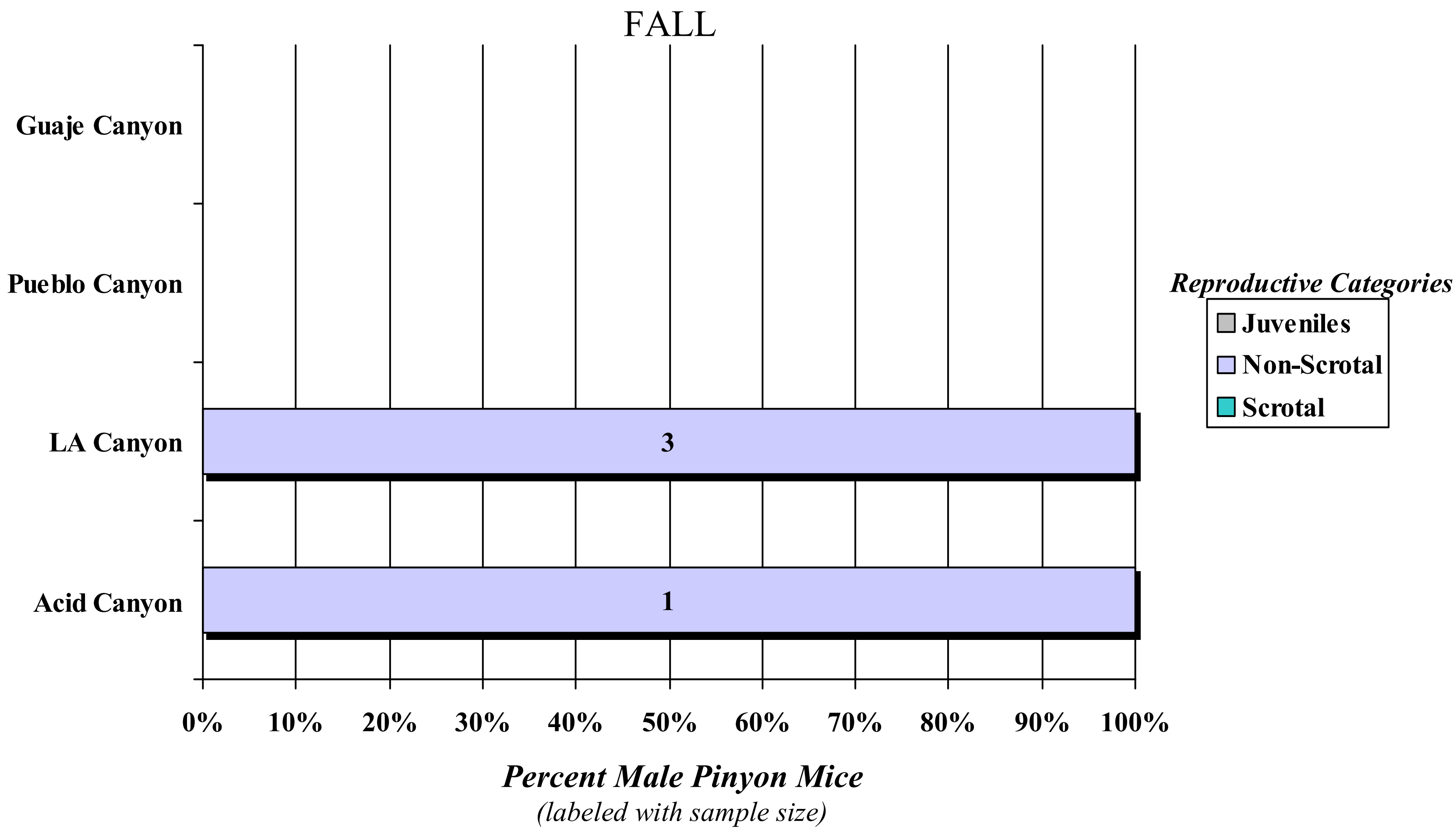


Figure 30. Reproductive status of male pinyon mice captured during the fall, 2002.

Table 5. Canyons with Sufficient Sample Sizes (denoted with an X) for Inclusion into a GLM, AOV of Body Weights by Season, Species, and Sex

	Acid Canyon	LA Canyon	Pueblo Canyon	Guaje Canyon
FALL				
Brush Mouse				
MALES	X	X		X
FEMALES		X	X	X
Deer Mouse				
MALES	X		X	X
FEMALES	X		X	X
SUMMER				
Brush Mouse				
MALES	X	X	X	X
FEMALES	X	X		X
Deer Mouse				
MALES		X	X	X
FEMALES		X	X	X

Summer, Female Brush Mouse

There were no differences (alpha = 0.05) in adult female body weights between brush mice captured in Acid, Guaje and LA Canyons (GLM, F distribution (F) = 0.87, Probability (p) = 0.4361). Mean weights ranged from 21.8 g (Guaje Canyon) to 25.8 g (LA Canyon). There were insufficient numbers of adult female brush mice (n = 0) captured in Pueblo Canyon during the summer to be included in the analysis. Only juvenile brush mice were captured in Pueblo Canyon (Table 5, Figure 31).

Fall, Female Brush Mouse

There were no differences in female adult body weights detected between brush mice captured in LA, Pueblo, and Guaje Canyons (GLM: F = 0.21, p = 0.8086). Mean weights ranged from 19.3 g (Guaje Canyon) to 20.2 g (LA Canyon). There were insufficient numbers of adult female brush mice captured in Acid Canyon during the fall to be included in the analysis of body weights. However, two adults were captured with an average weight of 22.5 g (Table 5 and Figure 31).

Summer, Male Brush Mouse

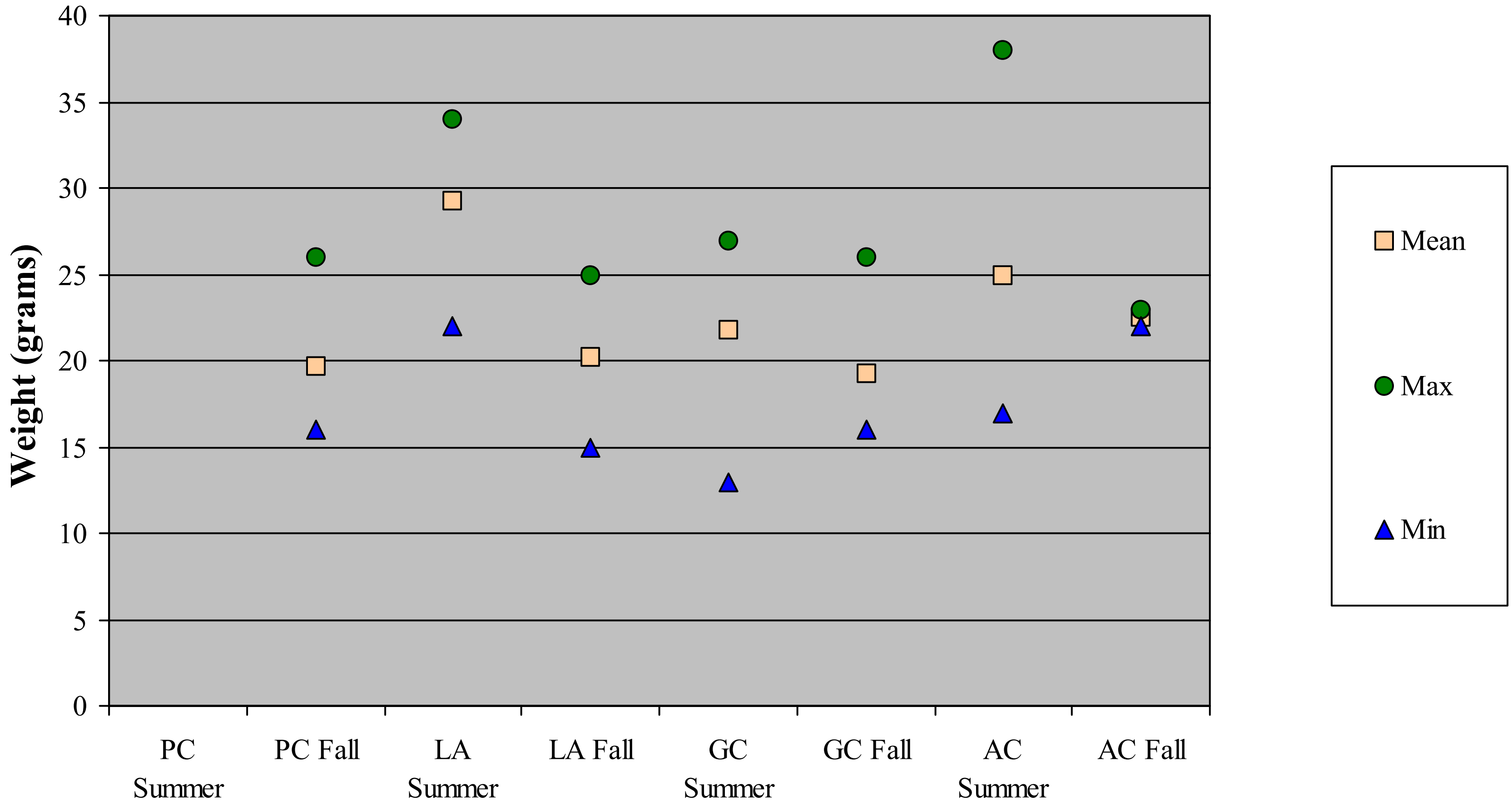
A sufficient number of adult male brush mice were captured during the summer from each canyon to test the differences in body weights of these males between the canyons (Table 5). Mean weights ranged from 14.0 g (n = 3) in Pueblo Canyon to 23.3 g (n = 4) in Guaje Canyon (Figure 31). A significant difference in body weights between the canyons was found and mean body weight from Pueblo Canyon was found to be statistically different than the other canyons (GLM: F = 8.39, p = 0.0008; Tukey MRT = Guaje, Acid, and LA>Pueblo [Figure 32]).

Fall, Male Brush Mouse

During the summer there were sufficient captures of adult male brush mice from all canyons to be included in the weight analysis but in the fall sufficient numbers were available only from Acid, Guaje, and LA Canyons. Weights ranged from 18.4 g (Acid Canyon) to 19.8 g (LA Canyon). No statistical difference was detected in these adult male body weights between the three canyons (GLM: F = 0.28, p = 0.7638). Only one non-scrotal male was captured in Pueblo Canyon and the body weight was 25 g (Table 5 and Figure 32).

Summer, Female Deer Mouse

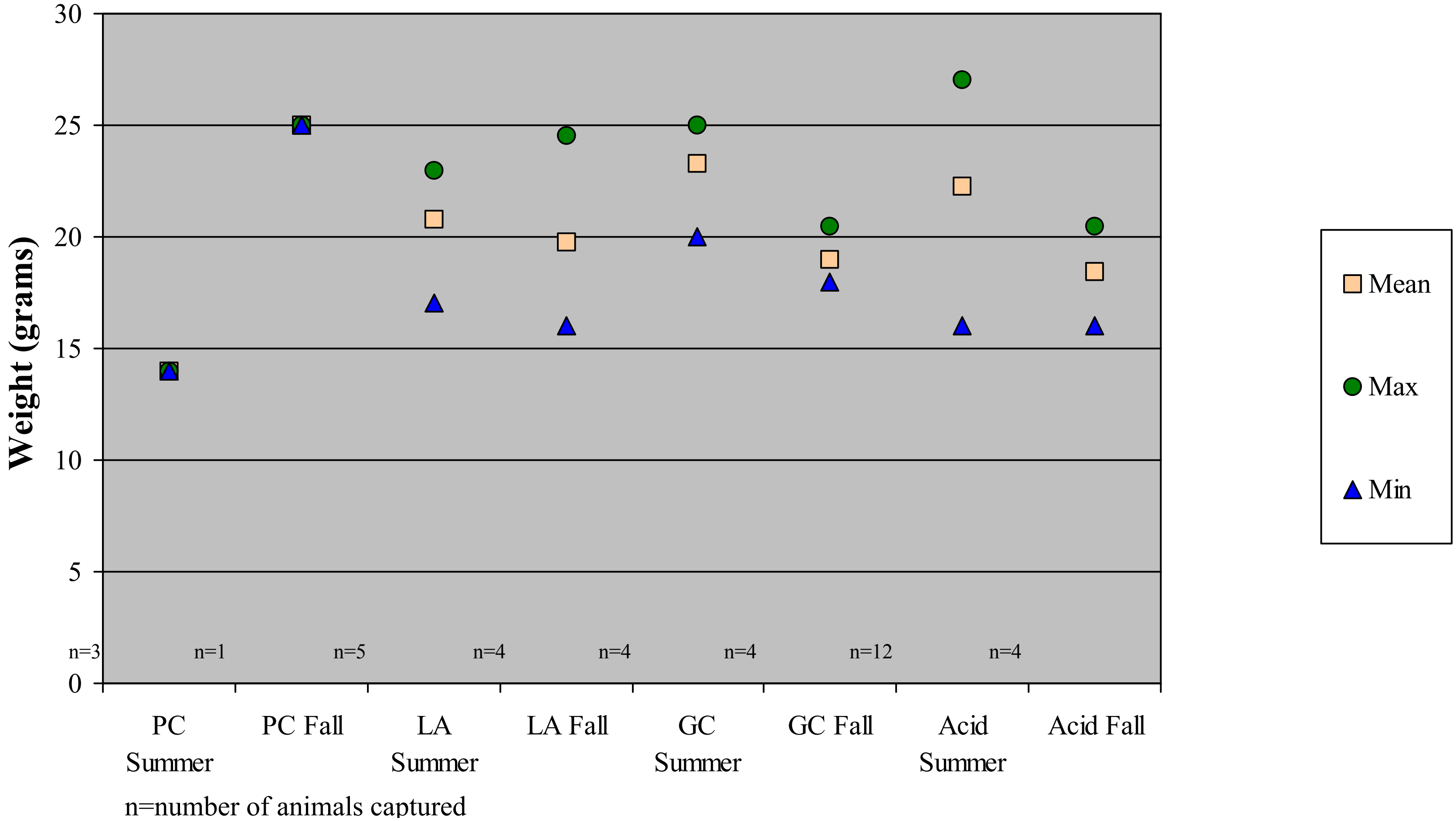
No statistical difference was detected in body weights of female adult deer mice captured between LA, Guaje, and Pueblo Canyons (GLM: F = 0.08, p = 0.9216). Mean weights ranged from 16.5 g (Pueblo Canyon) to 18.3 g (Guaje Canyon). Only one adult female deer mouse was captured in Acid Canyon with a weight of 14 g (Table 5 and Figure 33).



PC = Pueblo Canyon; LAC = LA Canyon, GC = Guaje Canyon, AC = Acid Canyon

** Brush mice were not captured in Pueblo Canyon during the summer

Figure 31. Mean, maximum, minimum weights of adult female brush mice captured in the summer and fall for all four canyons.



PC = Pueblo Canyon; LA = Los Alamos Canyon, GC = Guaje Canyon

Figure 32. Mean, maximum, minimum weights of adult male brush mice captured in the summer and fall for all four canyons.

Fall, Female Deer Mouse

No differences in mean body weights were detected (alpha = 0.05) between female adult deer mice captured in Acid, Guaje, and Pueblo Canyons (GLM: F = 2.96, p = 0.0977). Mean body weights ranged from 16.5 g (Guaje Canyon) to 19.8 g (Pueblo Canyon). There were insufficient numbers of adult female deer mice captured in LA Canyon during the fall to be included in the analysis of body weights. However, one adult female was captured with a weight of 13.5 g (Table 5 and Figure 33).

Summer, Male Deer Mouse

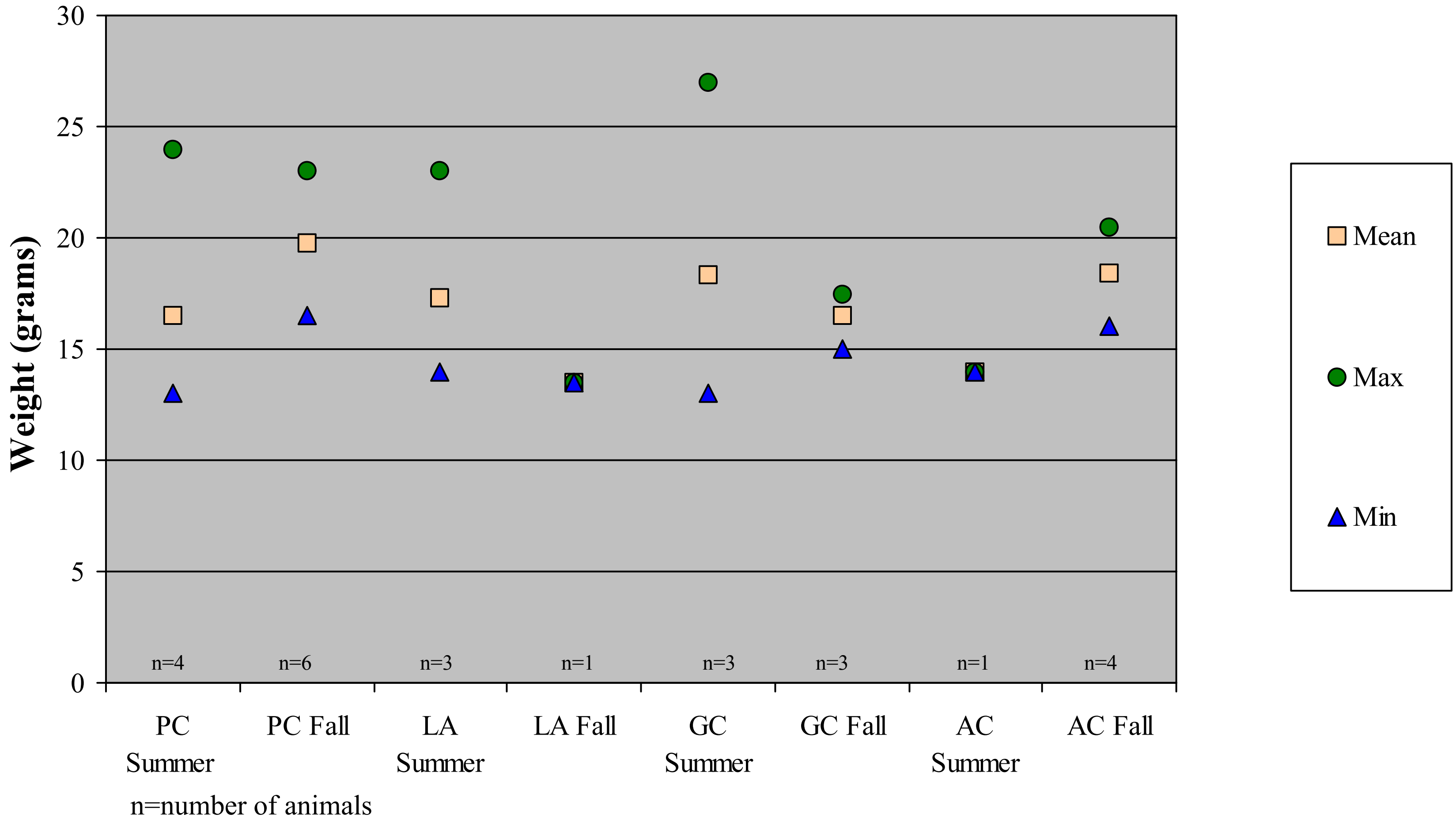
Body weights of adult male deer mice were compared across Guaje, LA, and Pueblo Canyons. A statistical difference was detected between the body weights from the three canyons (GLM: F = 4.78, p = 0.0167) and the Tukey MRT indicated that LA Canyon and Guaje Canyon had no differences in body weights as well as Guaje and Pueblo Canyons. However, body weights were found to be different between LA and Pueblo Canyons at the alpha = 0.05 level. Mean body weights ranged from 14.2 g (Pueblo Canyon) to 19.8 g (LA Canyon). Only two adult male deer mice were captured in Acid Canyon with an average weight of 16 g (Table 5 and Figure 34).

Fall, Male Deer Mouse

A significant difference was detected between mean adult body weights of male deer mice captured in Acid, Guaje, and Pueblo Canyons (GLM: F = 6.20, p = 0.0076). The Tukey MRT indicated that there were no differences in mean body weights between Acid and Pueblo Canyons and also between Pueblo and Guaje Canyons. However, a difference (alpha = 0.05) was detected between Acid and Guaje Canyons. Mean body weights ranged from 14.8 g (Guaje Canyon) to 18.4 g (Acid Canyon) (Table 5 and Figure 34).

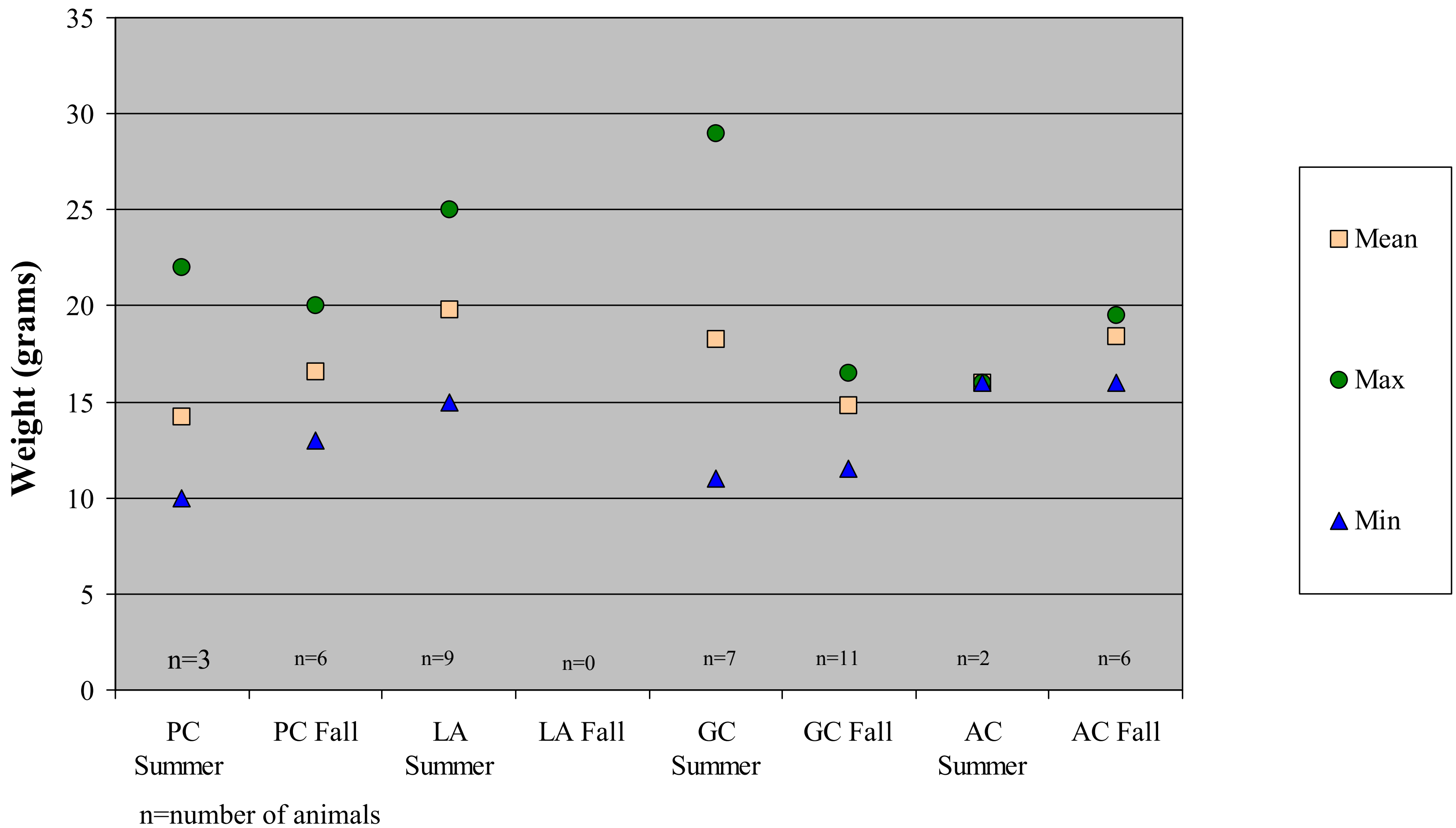
Mean Percent Daily Capture Rates

Mean percent daily capture rates were calculated for each canyon. Mean percent daily capture rates were calculated using 200 trap stations per canyon per day. All new and captured animals were considered in this analysis. Data from Guaje Canyon and LA Canyon were available from past trapping surveys and capture rates were calculated for comparisons to present data.



PC = Pueblo Canyon, LA = Los Alamos Canyon, GC = Guaje Canyon, AC = Acid Canyon

Figure 33. Mean, maximum, minimum weights of adult female deer mice captured in the summer and fall for all four canyons.



PC = Pueblo Canyon, LA = Los Alamos Canyon, GC = Guaje Canyon, AC = Acid Canyon

Figure 34. Mean, maximum, minimum weights of adult male deer mice captured in the summer and fall for all four canyons.

Summer

During the summer trapping session, Pueblo Canyon had the highest mean daily capture rate of 16% (includes central and eastern grids), and Acid Canyon had the lowest rate of 7.3%. Capture rates calculated for the Guaje Canyon trapping that occurred in 1994 (4.5%) and 1993 (3.25%) were much lower than the present rate (10.5%). LA Canyon rate of 13.5 had slightly higher rates than 1992 (11.67) but differed dramatically to those rates calculated for 1994 data (3.0% [Figure 35]).

Fall

In the fall, the daily mean capture rate decreased in all four canyons with Acid Canyon having the highest capture rate of 7.19% similar to summer and LA Canyon having the lowest rate of 2.7%. The previous years sampling in Guaje Canyon was conducted in the summer, but the capture rates calculated for 1993 (3.25%) and 1994 (4.5%) were similar to those in fall 2002 in Guaje Canyon (4.83%). Also, the daily mean capture rate in LA Canyon during 1994 (3.0%) was similar to the 2002 fall capture rate (2.67) but much lower than the rate found in 1992 (11.67 [Figure 35]).

Density Estimates

Density estimates were calculated only for those canyons and grids that were represented by a linear capture rate decreasing over time. Nonlinear rates result in an invalid estimator when using a Leslie's regression. Because sample sizes were small, standard errors generated from the regression were also small and are based on assumptions that may not be valid for our samples set (assumption of large sample size). However, density that we estimated still allows for a site-to-site comparison. Density was estimated for each grid in each canyon separately and data were not pooled from grid to grid. In each canyon (except Acid Canyon), the grids were set up with over 100 meters separation between them representing two distinct sampling areas. Multiple grids in each canyon act as replicate samples. LA and Guaje Canyons had previously been sampled for small mammals in 1993 and 1994. However, there was insufficient sample size to estimate density from these samplings and a year-to-year comparison was not made.

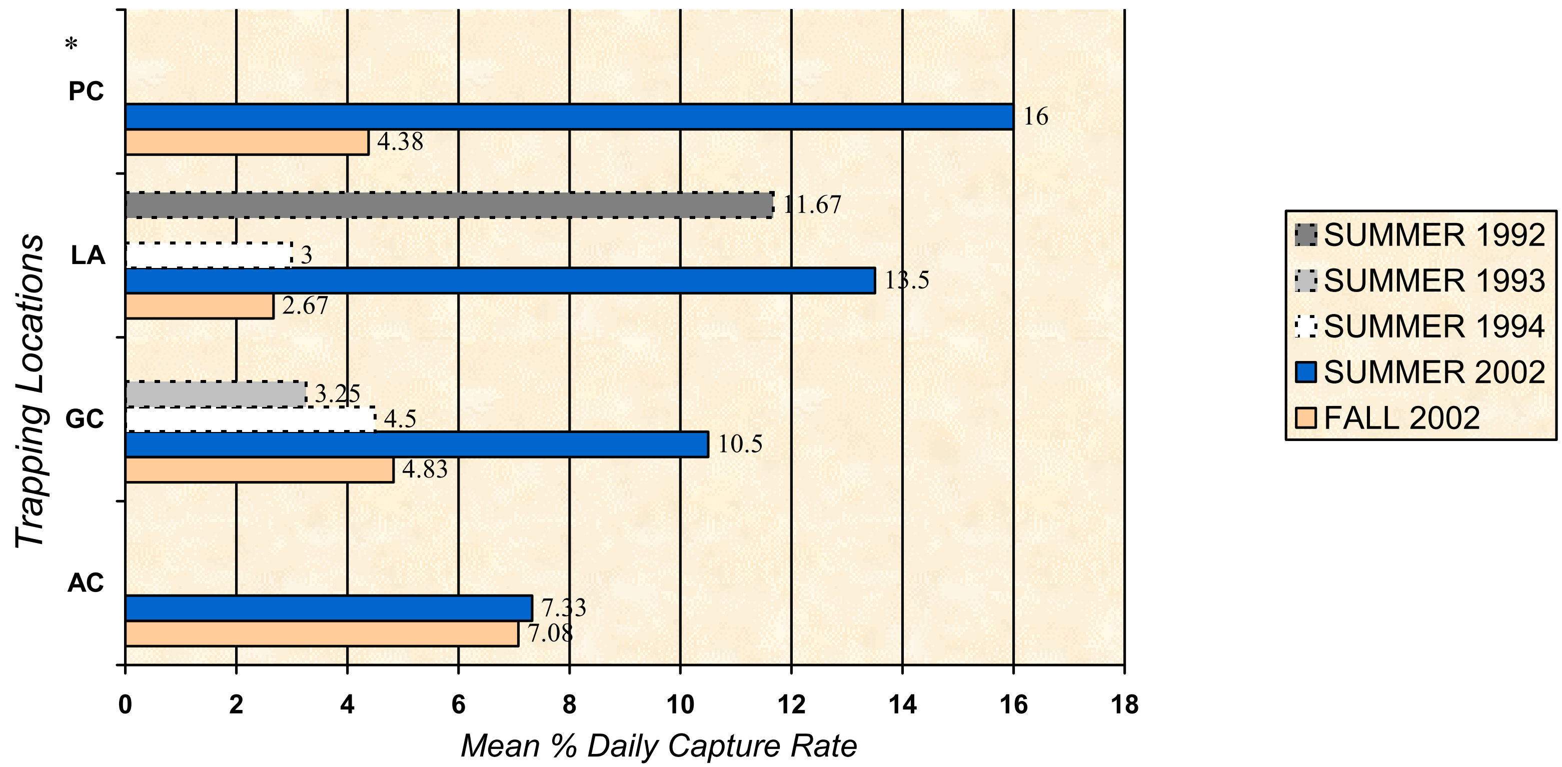


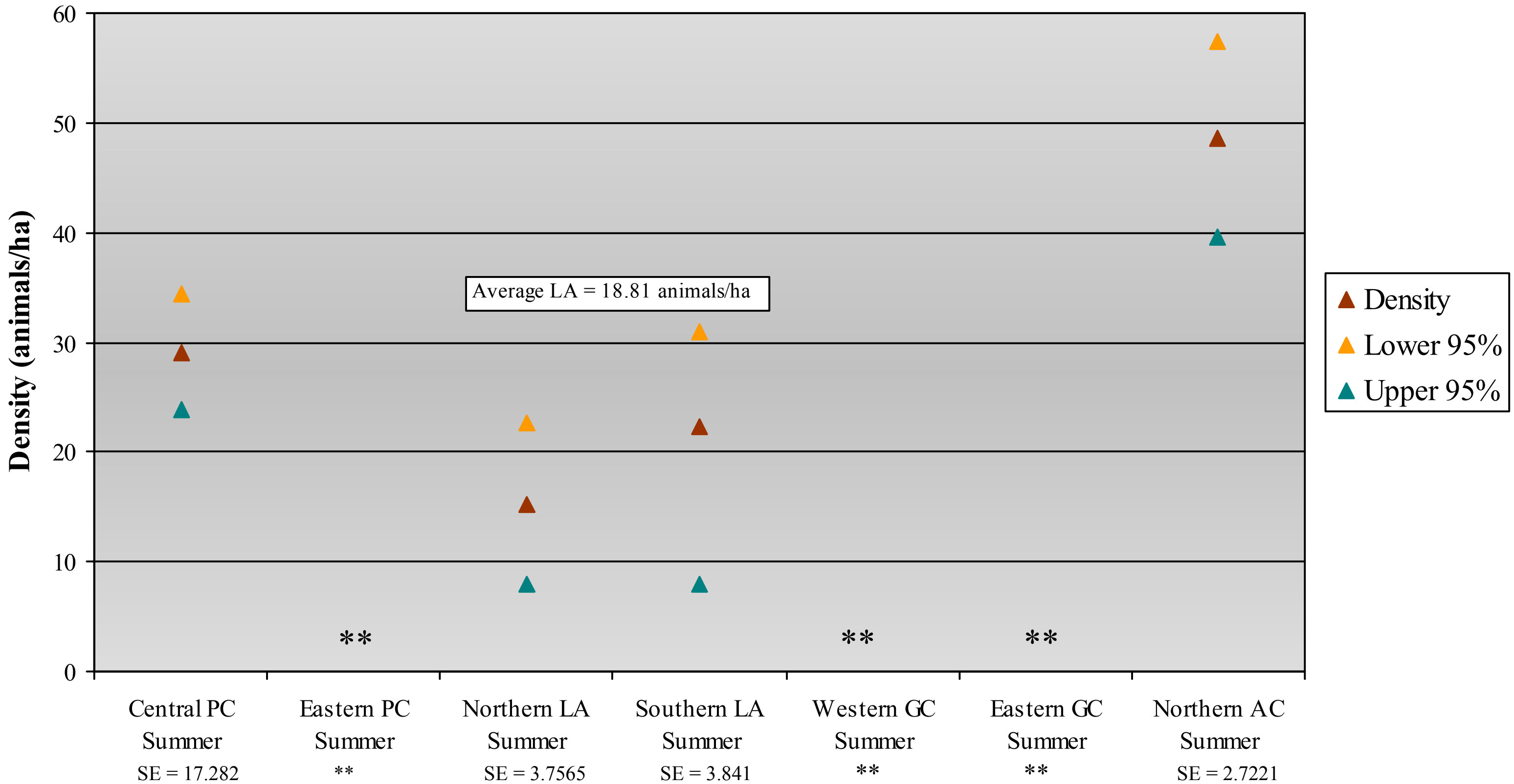
Figure 35. Mean percent daily capture rates for Acid (2002), Guaje (2002, 1994, and 1993), LA (2002, 1994, and 1992), and Pueblo (2002) Canyons.

Summer

The highest density of animals was estimated for Acid Canyon (based on a single grid) with 48.6 animal/ha and a standard error (SE) of 2.7. The lowest average density was estimated for LA Canyon at 18.81 animals/ha (northern grid = 15.3 animals/ha; southern grid = 22.31 animals/ha). Estimates were not calculated for Guaje Canyon because of nonlinear captures (eastern grid 2,2,5,8 and the western grid 3,8,4,9; Figure 36). The central and eastern grids of Pueblo Canyon were sampled in the summer. However, the eastern grid had a nonlinear capture (7, 7, 5, 8) and density estimates were not made. We estimated density of the central grid to be 29.12 animals/ha (SE = 17.282).

Fall

The western and central grids of Pueblo Canyon were sampled during the fall. The central grid had a nonlinear capture rate (6, 7, 5) and density estimates were not valid. Based on the estimate of the western grid Pueblo Canyon had the highest estimated density of 27.5 animals/ha and SE of 2.1 (Figure 37). Eastern Guaje Canyon grid had the lowest density estimate (13.5 animals/ha) with a SE of 0.0 but the average estimated density for Guaje Canyon was 15.47 animals/ha (based on western and eastern grid), higher than the average density of LA Canyon (13.92 animals/ha [nouthern grid = 14.67 animals/ha; southern grid = 13.16 animals/ha]). For the most part, density estimates decreased or remained the same in the fall when compared to the summer. Valid density estimates were not available for the summer in Guaje Canyon. However, capture rates were higher in the summer than in the fall and would lend credence to a higher possible summer density.



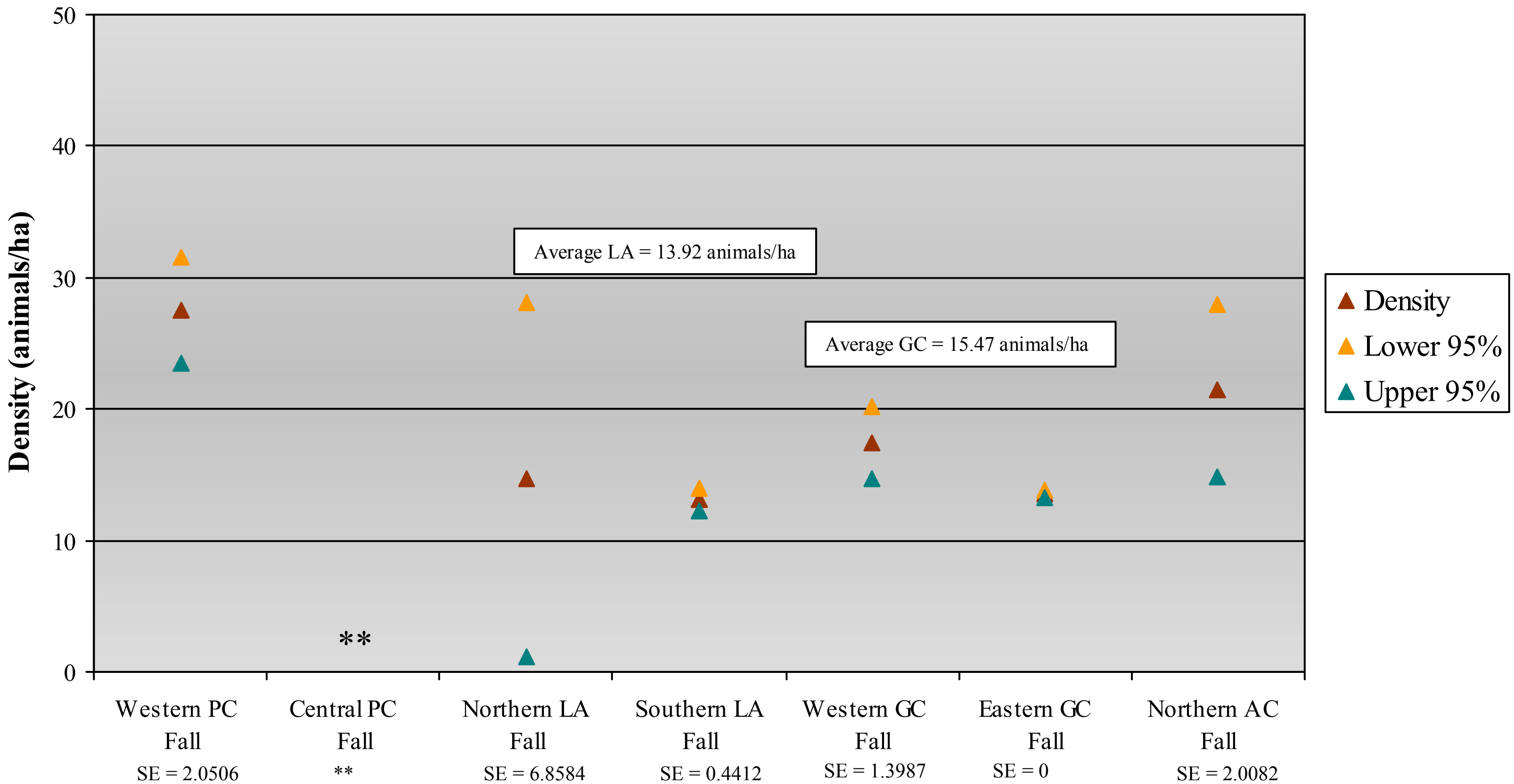
PC = Pueblo Canyon, LA= Los Alamos Canyon, GC = Guaje Canyon AC = Acid Canyon

*** Non-linear daily captures density estimate invalid. Lower PC had the following daily captures (7,7,5,8); upper GC had the following daily captures (3,8,4,9); lower GC had the following daily captures (2,2,5,8).*

Southern grid in Acid Canyon was not sampled for density analysis and

the western grid in Pueblo Canyon was not sampled during the summer.

Figure 36. Density estimates with 95% confidence levels and standard error (SE) for small mammal species captured during summer sampling in Pueblo Canyon, LA Canyon, Guaje Canyon, and Acid Canyon.



PC = Pueblo Canyon, LA = Los Alamos Canyon, GC = Guaje Canyon

*** Non linear daily captures density estimate invalid. Lower PC had the following daily captures (6,7,5).*

Southern grid in Acid Canyon was not sampled for density analysis and

the eastern grid in Pueblo Canyon was not sampled during the fall.

Figure 37. Density estimates with 95% confidence levels and standard error (SE) for small mammal species captured during the fall sampling in Pueblo Canyon, LA Canyon, Guaje Canyon, and Acid Canyon.

SUMMARY and DISCUSSION

A small mammal survey was initiated as one of the lines of evidence to assess whether there were potential adverse ecological effects due to the presence of metals, polychlorinated biphenyls, pesticides, and radionuclides in several canyons (Katzman 2002). Small differences were found in species composition, diversity, sex composition, and reproductive status between the four sites. Of the three investigation canyons, Pueblo Canyon had the highest diversity indices (summer: 1.64; fall: 1.91) as well as the highest number of different species captured (fall and summer equals five species captured). The reference canyon, Guaje Canyon, had the highest overall diversity index in the summer (1.92) and the second highest index for the fall (1.62). Four different species were captured in Guaje Canyon during both the fall and summer trapping. Diversity index in Guaje Canyon was higher in the summer and greater than the diversity in Pueblo Canyon even though more different species were captured in Pueblo. This is because diversity measures not only variety but the proportions as well. Guaje Canyon had an increased evenness over Pueblo Canyon during the summer trapping. Los Alamos Canyon had a measurable drop in the diversity index from summer (1.52) to fall (0.34) with only two species captured and the majority captured being brush mice. Such a drop in diversity could be the results of poor weather conditions affecting the fall trapping (heavy rains at night).

Some species were only captured in the investigation canyons (wood rats) and some species were only captured in the reference canyon. Differences in species composition are most likely a result of differences in habitat among the canyons and the trapping locations (Marsh and Dunham 2002). Guaje Canyon and Pueblo Canyon trapping areas were both in fairly wide canyon bottoms, but Pueblo Canyon received effluent discharge waters immediately adjacent to the eastern grid and downstream of the western and central grids. Also, Guaje Canyon trapping area was dominated with a grass understory and very little overstory. On the other hand, Pueblo Canyon was dominated by a ponderosa pine overstory with a scattering of junipers and piñons at the fringes and very little understory. Acid Canyon and LA Canyon sites were at a slightly higher elevation with ponderosa pine and mixed conifer overstory. In addition, Acid Canyon is a very narrow canyon in comparison to the other canyons. These differences in habitat affected the types and numbers of species captured. For example, pocket mice are most commonly found in grassland areas or dry riparian zones. Studies have shown that pocket mice are herbivores, eating plants almost exclusively (Findley et al. 1975), with a high seed intake. Their preferred food sources are most abundant in grassland areas that were common to the trapping area of Guaje Canyon but almost absent in the investigation canyons. In addition, pinyon mice are usually associated with coniferous woodlands and more specifically piñon-juniper woodlands (NMDGF 2000). Pinyon mice are rarely found in grasslands, pure stands of sagebrush, or oak woodlands (NMDGF 2000) explaining their absence from Guaje Canyon. Pueblo Canyon had the highest numbers of junipers and pinyons within and adjacent to the trapping area and this resulted in this site having the highest numbers of pinyon mice captured. Wood rats were taken in very low numbers in only two of the canyons (Pueblo Canyon, n = 3; Acid Canyon n = 1) and capture locations were always near a rock outcrop or in a downed woodpile, areas preferred by wood rats.

Sex ratios were compared in each canyon by season using an assumption of equal distribution between the two sexes (only adults were considered). Samples sizes were too small in many cases to run the Chi-square analysis. For sites where there were sufficient captures, some differences were detected. In the summer, Pueblo Canyon had a significantly higher proportion of male adult deer mice to adult female deer mice, but in the fall male and female adult deer mice were found in equal proportions. In the fall, Pueblo Canyon had significantly higher proportions of females to male adult brush mice. During the summer trapping session in Pueblo Canyon only male brush mice (n = 3) were captured but we had insufficient sample size to conduct a Chi-square analysis. In the fall, Guaje Canyon had a significantly higher proportion of male adult deer mice to female adult deer mice where in the fall no differences were detected. No other differences were detected, but sample sizes were too small in many cases to perform an analysis. Sample size was a major factor in conducting this analysis and more data are needed to make any further comparisons and conclusions.

Reproductive status of males differed slightly among the canyons. Juvenile males were captured in all canyons except Guaje Canyon. LA Canyon and Acid Canyon were the only canyons that had males from each reproductive category present during an individual trapping session. There were also small differences in the reproductive status of females within the canyons. Juvenile females were not captured in the summer or fall in LA Canyon. Guaje Canyon was the only canyon with all four female reproductive categories represented, but not necessarily for all species. These differences could be the result of environmental pressures such as drought and daily trapping conditions (weather). During the fall trapping, weather conditions changed dramatically with temperatures being 30 to 40º F with snow and rain occurring in some of the trapping sites.

In general, body weights of adult small mammal species were similar across canyons. However, during the summer in Pueblo Canyon male brush mice had significantly lower weights than male brush mice from other canyons. Differences in weights could be the result of capturing a higher percent of younger males (non-scrotal) during the summer in Pueblo Canyon resulting in a lower mean body weight. No differences in weights were detected in male brush mice during the fall session, but there were insufficient numbers of Pueblo Canyon males to be included in the analysis. Our study also showed a statistical difference between male deer mice mean body weights during the summer from LA and Pueblo with Pueblo having lower weight males. Again this could be the result of capturing all non-scrotal males in Pueblo Canyon and capturing 86% scrotal males in Guaje Canyon. Another difference was detected in mean body weights of male deer mice captured in the fall. Acid Canyon was found to be significantly different from Guaje Canyon with Acid Canyon having heavier male deer mice. In this case, all canyons had captures of non-scrotal males only. It is hard to determine exactly the cause of this difference but age of the non-scrotal males could be one. Additional reasons could be environmental, relating to food source availability and competition. More non-scrotal males were captured in Guaje Canyon ($n = 11$) than in Acid Canyon ($n = 6$) and competition for food resources may have been higher in Guaje Canyon. Further studies would be needed to determine if this is an actual trend.

Pueblo Canyon and Acid Canyon had the highest density estimates and Guaje had the lowest calculated density. Although density estimates and daily capture rates declined from summer to fall for most of the canyons, the summer capture rates in LA and Guaje

Canyons were higher than historical data in most cases. Changes in density estimates and daily capture rates over the 2002 trapping periods were most likely a direct result of trapping conditions and, possibly, trapping pressure. Weather conditions may have had a direct impact on trapping success reducing their forage time and potential to be trapped. Density may have also decreased because of the removal of individuals in the summer. Because of drought conditions adding stress on the population, the population may not have had enough time to recover from the removal of individuals during the summer trapping and thus resulted in lower density estimates in the fall. Based on the two 2002 sampling periods, results from the four sites overlap and differences observed among the sites are most likely related to differences in habitat and environmental conditions (drought and weather). More thorough evaluation of potential adverse effects due to COPECs is pending analyses of other lines of evidence relevant to small mammals.

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